THE GLASS INDUSTRY

VOLUME 28, NUMBER 9, SEPTEMBER, 1947

FUELS FOR AMERICAN INDUSTRY

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The interest in nuclear energy following the development of the atomic bomb and the high hopes that have been expressed in the potential contribution of this form of energy to fuel and power supply offer an occasion to examine the fuel requirements of a modern industrial economy. We use, annually, in the United States, the fuel equivalent of a billion tons of coal, more or less. For example, in the decade ending 1945 we used, in a year of low activity, the equivalent[1] of 760 million tons of coal and in a year of high activity nearly 1200 million tons. Among the several fuels this is distributed as follows:

(Millions of Tons or Barrels)

Fuel	Low Year	1945
Bituminous coal, tons	378	560
Anthracite, tons	45	52
Motor fuel, barrels	519	696
Kerosene, barrels	55	76
Distillate fuel oil, barrels	117	226
Residual fuel oil, barrels	291	523
Natural gas, billions c/f	3711	3875
Water power, fuel equivalent, tons	30	50

We derive our fuel and power requirements, in the main, from four natural sources—coal, petroleum, natural gas, and water power. Oil in shale may at some time become a source of fuel and to this must be added a possible contribution to power requirements by nuclear energy.

In support of this high annual requirement of energy materials, the United States is unusually well endowed, although there are certain deficiencies that impose limitations upon industrial development in certain localities.

The mineral fuel reserve of the United States has been estimated by the Bureau of Mines and may be accepted as a tentative inventory for the moment, subject to periodic revision upward or downward as the surveys become more detailed and evaluations become more dependable. In the accompanying table modified from a table prepared by A. C. Fieldner[2] are shown the reserves of all kinds of mineral fuels in solid, liquid, and gaseous forms.

TABLE I—ESTIMATED MINERAL FUEL RESERVES OF THE UNITED STATES[1]

Description	Reserve Jan. 1, 1946	Reserve Jan. 1, 1946[2] Equivalent billion of net tons, bituminous coal, 13,000 B.t.u. lb. calorific value	Per Cent of Total Fuels
Anthracite, billions of net tons	15	15	0.6
Low-volatile bituminous coal, billions of net tons	52	56	2.2
High-volatile bituminous coal, billions of net tons	1351	1403	54.2
Sub-bituminous coal, billions of net tons	819	598	23.1
Lignite, billions of tons	939	484	18.7
Total coal	3175	2556	98.8
Petroleum, billions of barrels	208	4.8	0.2
Oil from oil shale	92	21.2	0.8
Natural gas, trillions of cubic feet	135	5.2	0.2
Total all fuels		2587	

[1]Source: U.S. Bureau of Mines.
[2]Heating values used in conversion: Anthracite, 12,700 B.t.u. per lb.; low-volatile bituminous coal, 14,000 B.t.u. per pound; high-volatile bituminous coal, 13,500 B.t.u. per pound; sub-bituminous coal, 9,500 B.t.u. per pound; lignite, 6,700 B.t.u. per pound; crude petroleum, 6,000,000 B.t.u. per pound; natural gas, 1,000 B.t.u. per cubic foot.

The minimum thickness of beds included in the U. S. Geological Survey estimate of reserves is 14 inches for bituminous coal and anthracite, two feet for sub-bituminous coal, and three feet for lignite. Coal beds lying

[1]The fuel equivalents are calculated as 4 barrels of liquid fuel and 25,000 cubic feet of natural gas to one ton of coal.
[2]Fieldner, A. C. The National Fuel Reserves, *Mechanical Engineering*, Vol. 69, No. 3, March, 1947, p. 221.

more than 3,000 feet below the surface were not included in the estimates. The estimated coal reserves do not allow for losses in mining; that is, they are not limited to recoverable coal as is the case with the petroleum and natural gas estimates.

The provisional estimate of America's fuel resources needs some qualifying remarks. A large portion of the coal reserves are in the western mountain states and presently of local usefulness only. Under the present geographical pattern of American industry, much of this coal must be considered unavailable. Although 85 per cent of the annual coal requirements of the nation come from the states of West Virginia, Pennsylvania, Ohio, Kentucky, Alabama, Illinois, Indiana, and other states east of the Mississippi River, more than 60 per cent of the nation's coal tonnage reserve lies in states west of the river.

While the aggregate tonnages of coal reserves appear enormous, the geographical distribution of coal requirements show little relationship to the distribution of coal reserves. Fourteen industrial states east of the Mississippi and north of the Ohio River used, in 1945, about 71 per cent of the total coal used, excluding railroad and vessel fuel, exports, and coal made at the mines. These states, on the other hand, have only 15 per cent of the indicated national reserve. The bulk of the high- quality coking coal occurs in the Appalachian region. The so-called smokeless coals of southern West Virginia are not widely duplicated. The patterns of industrial location in the United States are shaped upon the high quality, low cost coals of the Appalachian and Illinois-Indiana Fields, the iron ores of the Lake Superior district, and the low-cost water route over the Great Lakes. A decline of coal supply in the present strategically located supply districts can have serious consequences upon the cost of assembling ores and fuels and on the productiveness of the American industrial economy.

Oil. Between the quantity of known and proven reserves of 21 billion barrels of oil and the quantity which will ultimately be recovered is a large but indeterminate tonnage. The "balance on hand" of proven reserves has never been very large in ratio to annual requirements. Annual explorations by the petroleum industry for added known reserves to replace depleting fields is an accepted characteristic of this industry. The record of annual discoveries since the beginning of the oil industry gives assurance that all fields have not yet been found and that substantial additions to the present "balance on hand" may be anticipated. This type of bookkeeping reserve also applies to the natural gas industry.

Function of Fuels

The function of fuels in our existing pattern of productive economy is manifold and varied. The fuels, in the raw state as mined or produced from wells, have but a limited and restricted usefulness in industry. Varying degrees of fuel preparation are necessary if the tasks of industry are to be accomplished. Fuels are needed in solid, liquid, and gaseous forms in several types of each. To this must also be added electrical power—energy in a non-material form. The types of engines, using this term in a very comprehensive manner, must also consist of many types and forms. Among these, power providing devices are steam engines (and boilers), internal combustion engines, hydraulic engines, dynamos, compressors, storage batteries, blast furnaces, ovens, retorts, cookers, boilers, hot blast stoves, etc.

Diversity of form and properties in the natural fuels has added versatility to the economic pattern. The outstanding example of this is the discovery of petroleum and its subsequent production cheaply in large quantities. This laid the basis for the development and extensive use of the automobile and has stimulated the development of a large manufacturing industry and a host of associated industries serving the automobile owner as manufactures, or service agency.

The growth of our modern industrial economy and its increasingly complex development calls for several specifically prepared fuels which permit of no substitution. The tendency in fuel preparation also is to increase in number of specially prepared fuels as a means of increasing the efficiency with which the fuel performs in a given operation.

The function of fuels in industry may be grouped broadly into two general categories, the supply of heat and power. Within each of these groups there is so wide a range of requirements that a correspondingly wide variety of prepared fuels is needed to accomplish the desired results. Some industrial processes require specially prepared fuels for which substitution is impossible or impracticable, whereas other processes are tolerant in their fuel requirements. This is especially true in the so-called "heat-using" industries. In the "power-using" industries, a wide variety in size and in function of power units calls for a need of fuels in various specialized forms. Conversely, the availability in the United States, of ample quantities of fuels, in the solid form, in liquid, and gaseous fuels at relatively low costs provides an opportunity for development of a range of power-using devices that would be out of the question if the supply of fuel in its natural state were limited to coal alone.

In "heat" operations, there are two general classes of requirements, (a) smelting of ores—a reduction process requiring both heat to raise the ores to a temperature in which the desired reactions take place and carbon to unite with the oxygen in the ores. In this case a special type of fuel is required. A second general class of heat operations involve mainly production of heat to raise process substances to high temperatures.

Examples of this are heat treatment of metals, such as the heat treatment of ingots in the soaking pit, heating of billets, sheets, rods or even in preparation for rolling or drawing. Another group of heat operations includes raising of process steam, heating air for blast furnaces, drying, cooking, boiling, vaporization, or fusion.

In "power" using industries, the motor varies from the huge stationary turbine of the power station, fired by coal and driven by steam, to the small, mobile, internal-combustion engine unit of a lawn mower. Or a combination of the steam turbine as a prime mover and power transmitted to a distant point through the generator to an electric motor, frequently of fractional horsepower in size.

In the myriad applications of heat and power to industry, the selection of fuels in each particular use is governed by two general considerations—technology and relative cost. Technology sets the limit within which one fuel can be substituted for another. Price is the selective process by which one out of several possible alternative fuels is chosen.

Fuel Users

In the American economy there are seven generalized areas of economic activity in which fuels and power are used extensively; namely, manufacturing, power generation, agriculture, mining, transportation, construction, and domestic heating. Accurate and comprehensive data in each of these fields are rather meagre except possibly for manufacturing, transportation, and power generation.

The manufacturing industries use from 250,000,000 to 300,000,000 tons of fuel (coal equivalent annually). Of this from 60 to 90 million tons are used in the preparation of coke for metallurgical use. The particular significance of coke here is its unique and distinctive contribution in industry.

The reduction of iron ore in the blast furnace using coke as a fuel is at present the only practical method of obtaining one of the basic requisites of industrialization —cheap steel. Other methods of obtaining raw iron have been proposed but, to date, none shows any possibility of replacing the blast furnace with heat supplied by coke.

With special exceptions the manufacturing industries other than iron and steel show no particular fuel preference. In the majority of cases, cost is probably the most important factor. The quantities of fuels consumed in these diverse groups of industries are approximately 80 to 100 million tons of coal, more than 100 million barrels of fuel oil, a billion cubic feet of natural gas, more or less, and some manufactured gas. The industries in which special fuel requirements prevail or where certain preferences appear to exist, are petroleum refining, carbon black manufacture, pulp and paper mills, primary smelting and refining of non-ferrous metals, and bread and other bakery products.

Fuels in Power Generation

Cost of fuel is the dominating factor in the selection of fuels for electric power production. In terms of importance as a source of heat energy for electric generation coal is dominant to the extent of about 80 per cent. The remaining 20 per cent represented by oil and gas is used mainly in the Southwest and Pacific states, where coal is scarce and costly and oil and gas are abundant.

Fuels in Transportation

In the aggregate the American transportation system requires more fuels than any other segment of the American economy. Included in this system are the railroads, the fleet of passenger automobiles, the growing numbers of busses and trucks, and water craft. The railroads use approximately 20 per cent of the coal output of the country, the amounts varying from 80 million to 125 million tons a year depending upon the level of business activity. Coal for ships' bunkers is yielding to fuel oil for steam generation or to Diesel-powered craft. Altogether, coal consumption on ocean and lake vessels is less than 3 million tons.

Passenger cars, busses and trucks consume a quantity of motor fuels slightly in excess of 50 per cent of crude petroleum produced each year. In addition to these, railroad locomotives and ships' bunkers consume an additional 10 per cent. Altogether over 60 per cent of crude petroleum output is used as transportation fuels. In fueling these several transportation services, the highly specialized nature of motor fuel, for which there is no substitute, for automotive units is perfectly obvious. The Diesel engine is achieving dominance in the lake and ocean vessels.

A summary of solid and liquid fuel requirements in the major transportation services in the country in 1941, a pre-war year, were as follows:

(Figures Are in Millions of Tons for Coal and Millions of Barrels for Oil)

	Coal	Oil
Railroads	97.4	85.5
Colliery fuel	2.7	67.6
Passenger automobiles	—	425.0
Busses	—	15.0
Trucks	—	144.0

The war necessarily upset the fuel consumption pattern by increasing demands for all fuels and vastly expanding certain requirements. For example, fuel oil requirements of the Army, Navy and Coast Guard rose from 17 million barrels in 1941 to 144 million barrels in 1944. Apart from the war needs, there was in evidence a tendency toward further increase in use of fuel oil by railroads and ships' bunkers away from coal.

Interest centers upon the changing character of locomotive power and fuel use in railroad transportation. The dominant, almost exclusive, position of the coal-fired steam locomotive is being challenged by the Diesel engine. In the short space of less than one decade the Diesel has risen from a negligible position to a 10 per cent share of freight and passenger business. As of March 1, 1947, orders for new locomotives run about 629 Diesel, 45 steam, and 6 electric.

From 1940 to 1945 Diesel fuel consumption has risen from 81 million gallons to 454 million gallons. The Diesel locomotive, however, is not unchallanged as the only alternative to the picturesque but inefficient steam locomotive. Plans for the development of a locomotive powered by a coal-fired gas turbine are in progress and tests on this development are being awaited with interest.

Fuels for the Domestic and Retail Market

Cost and convenience both are important elements in the selection of a fuel for domestic use. The favor with which oil and natural gas are regarded is shown in their rapid rise in the last decade.

DOMESTIC HEATING

TABLE II—RETAIL DELIVERIES OF DOMESTIC FUEL

Year	Coal Thousands of tons Deliveries	Index	Oil Thousands of bbls. Sales	Index	Gas Millions of cu. ft. Consumption	Index
1936..	84,200	100	99,257	100	345,000	100
1937..	80,076	95	116,617	117	371,844	108
1938..	68,520	81	118,323	119	367,772	106
1939..	71,570	85	136,232	137	391,153	113
1940..	87,700	104	160,379	162	443,646	128
1941..	97,460	115	167,514	169	447,000	130
1942..	104,750	124	168,989	171	498,537	144
1943..	122,764	146	155,251	156	529,444	153
1944..	124,906	148	152,203	153	582,000	169
1945..	121,805	145				

In spite of the trend in this direction there are certain characteristics of this market which will reserve for solid fuels a substantial share of the market. Natural gas is limited to urban centers with pipe line connections or the possibility thereof. Fuel oil faces an uncertain price

future as indicated by the constantly increasing costs of finding and recovering crude petroleum.

Fuels used in agriculture and in the construction industries are difficult to estimate quantitatively.[3] Of the two agriculture has lent itself more adaptable to mechanization and the application of mechanical power than the construction industries. Although both coal and liquid fuels are used, the most important development in both of these industries is that of the internal combustion engine in mobile power units as applied in a wide variety of ways.

The increase of productivity manifest in agricultural production and the potentialities of higher productivity in the construction industries through further mechanization will have the effect of augmenting the demand for the liquid fuels. The large demand for liquid fuel in this nation prompts one to analyze the unique contribution of this form of fuel to the productive economy. This fuel is associated primarily with the automobile habit of the American people but its association with the rise and many sided development of the internal combustion engine is a factor of far reaching consequences. Although the internal combustion engine was practically developed in 1860 and the modified Otto engine was invented in 1876, the period of rapid expansion in the use of this engine did not occur until the inception of the automobile industry with the construction of the first car in 1892. The petroleum industry, which was then and still is practically the sole source of motor fuel (gasoline), had been in existence since Colonel Drake opened the first well at Titusville, Pennsylvania, in 1839. However, the petroleum industry had only a slow growth until the automobile manufacture began its rapid expansion, and before the era of the automobile the principal refined product of crude oil was kerosene and not gasoline. While it would not be correct to say that the existence, in abundance, of a low cost motor fuel acted as a stimulus to the invention of the automobile and its subsequent production, it is correct to state that only the rapid expansion of this cheap and abundant fuel made it possible for the automobile registration to rise from 8,000 in 1900 to 29,418,000 in 1941. And even this could not have been accomplished if refining technique had not kept pace with the demand and increased motor fuel recovery from 18 per cent of the crude to 45 per cent of the crude.

The growth of the automobile manufacturing industry with the successful adoption of the internal combustion engine was accompanied by significant changes in power and fuel developments in other segments of the economy.

The first is the trend toward the use of the internal combustion engine, including the Diesel type, as a prime mover in industry. The displacement of steam by Diesel-electric locomotives or railroads, in local electric power plants, on ocean vessels, and in transport trucks on highways, is evidence of this trend. This type of engine also initiated the transformation of agriculture into a mechanized industry, a process which is still under way.

The trend toward the use of internal combustion engines accelerated the search for sources of liquid fuel from sources other than petroleum due to apprehension over the possible decline of petroleum discovery and supply. Without doubt the costly investigations on the liquefaction of coal through hydrogenation, or gasification and synthesis, and on the extraction of oil from shale are being undertaken only because the advantages of the internal combustion engine over steam are such as to justify this type of fuel preparation rather than run the risk of giving up many of these power developments.

[3]The Public Roads Administration gives a figure of approximately 1 billion gallons of gasoline used for agricultural purposes in 1945.

[4]Supplement to *American Scientist*, October, 1945, Vol. 33, No. 4.

The Role of Nuclear Energy (Atomic Power)

So much has been promised, or threatened, by the development and utilization of nuclear energy that a discussion of its potential role as a source of power should be included. The apparently possible methods of converting nuclear energy into useful forms of power have been widely discussed since the release of nuclear energy was first made public and only the briefest reference will be made to it in the present paper. We are concerned, rather, with a discussion of the interdependent relationships of nuclear power with the presently existing forms of fuel and power.

When nuclear energy is applied, the starting point is heat, picked up by water, air, or a special heat-transfer fluid. Incidentally, while the possibility of converting nuclear energy directly into electrical energy without going through the heat form has been mentioned, there is no prospect in sight that this will materialize.

Present discussion centers around three possible applications of nuclear energy: (1) the production of electrical (or mechanical) power through raising steam for steam turbine operation, (2) atomic powered gas turbine, and (3) raising steam, hot water, or air for domestic heating or for industrial process heat.

The production of electrical energy in power stations in which the usual forms of fuel have been replaced by fissionable material is regarded as technically possible, although at costs higher than the cost of electrical power from fuel burning stations. Two suggestions arise in connection with this proposed use of nuclear energy: first, that the cost may be materially reduced, or conversely, coal costs may go up and resume the existing differential in fuel costs; and secondly, the substitution of fissionable material for coal or oil will release a power plant from the restrictions of location imposed by the requirements of large volumes of cooling water. The first suggestion, that of substantially lower costs of nuclear fuel, must be considered within the realm of possibility, and carries with it the possibility of competing with coal or oil.

". . . we must avoid the temptation to overstress the economic importance of lower-cost power fuel. Fuel cost is only about 17 per cent of the gross receipts of the electric utilities. Here's another way to put it: If, after allowing for transmission losses, one kilowatt-hour delivered to the consumer from modern plants represents a consumption of 1.5 lb., and if the coal costs $5.00, a ton cancellation of the coal bill could not save more than ⅜ of a cent per kilowatt-hour. And atomic energy will certainly not be free."[4]

A wider freedom in selection of power plant sites occasioned by dispensing with the need for large volumes of cooling water must be regarded reservedly. One must bear in mind that the production of electrical power and its delivery for use in manufacturing plants is but one element in a complex productive economy. Water re-

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COLORED GLASSES

A Review of Part V of a Monograph* by W. A. Weyl
Appearing in "The Journal of the Society of Glass Technology," Sheffield, England

PART VI

Fundamentals of Fluorescence

The consideration of fluorescence in connection with color is logically derived from the question of the energy balance in light absorption. From this viewpoint, fluorescence, that is regaining the energy of the absorbed light by reemission, is the "normal" phenomenon, leaving non-fluorescence to be explained. If no fluorescence takes place, or if the energy of fluorescence is less than that of the light absorbed, the balance can be accounted for either by an increase in temperature or by a chemical change in the glass. The latter case introduces the subject of color changes under irradiation, for instance, the discoloration of glass in sunlight, termed solarization.

The consideration of fluorescence is further justified by the increasing public interest and commercial importance of fluorescence in modern technology. The presentation is novel in approach and is very extensive compared to the sketchy information on fluorescent glasses found in most standard books on fluorescence.

In addressing glass technologists and chemists the author appears to have felt that fluorescence requires a more thorough introduction than any of the subjects treated in earlier sections. It will be appreciated that this discourse on the fundamental mechanism of fluorescence does not presuppose that the reader is a scholar in the field of physics.

Weyl's Classification of Fluorescent Glasses

The specific part of the discussion of fluorescent glasses is planned on the basis of a classification proposed by Dr. Weyl himself. The classification is based on the fluorescence center, that is, the local source of the fluorescence in the glass. In Dr. Weyl's four classes the centers are: (1) Fluorescent crystals embedded in the glass, e.g., zinc sulfide. (2) Other crystals to which the glass furnishes a "fluorescence activator" like manganese. In certain opal glasses these crystals may form from the clear glass in a separate process. (3) Atoms or molecules, energetically separated by the glass structure from each other, e.g., silver atoms or cadmium sulfide molecules. (4) Ions, which are analogous to the coloring ions, and may be considered part of the glass structure proper.

First Class of Fluorescent Glasses: Glasses with Active Crystalline Centers, "Fluorescent Enamels"

Crystals composed of oxides, sulfides, and silicates activated by impurities (activators) such as copper, silver, and manganese are often refractory enough to be embedded without destruction in glasses melting below 800°C. (enamels). When Sauvage and Guntz invented the "fluorescent enamels" they used a zinc oxide enamel in which activated zinc sulfide remained insoluble.

In this group the glass has no other function than that similar to the resin in a luminous paint.

Second Class of Fluorescent Glasses: Glasses with Activated Crystalline Centers, "Fluorescent Opal Glasses"

Examples of materials capable of crystallizing from a glass melt are alkali fluorides, apatite $(3Ca_3(PO_4)_2)CaF_2$, zinc sulfide and zinc silicate. The zinc silicate can be activated by the presence of manganese in a glass from which the silicate is precipitated on cooling. A glass of this type was invented by W. Haenlein. The zinc silicate in these glasses is not present in its stable (Willemite) structure, but in a new, cristobalite-like structure; it has been studied by various authors, particularly Linwood and Weyl, who were able to derive its analogy to cristobalite. H. Fisher produced fluorescent glasses by stirring into the completely melted glass containing an activator such as manganese insoluble crystals of Al_2O_3 or zinc selenide.

Third Class of Fluorescent Glasses: Glasses with Molecular and Atomic Centers

The chief requirement to prevent absorbed light (UV) energy from being dissipated in the form of heat is relative isolation of the recipient center. A very substantial portion of matter is capable of intimate linkage with the main constituents of a silicate glass and, therefore, incapable of such isolated existence. On the other hand, for the few types of matter incompatible with the glass structure, the glass provides the necessary medium for isolating the atoms or molecules of this type from each other.

The neutral atom of metallic elements is the most typical matter incapable of intimate interlinkage with the main glass body. To constitute fluorescent centers the atoms must not be connected with each other in a metallic form, but isolated as in the vapor state. The so-called ruby glasses are analogous to "frozen-in" metal vapors. This condition, referred to in the earlier section on elemental colorants, is also conducive to fluorescence.

A. Silver Glass. The elemental fluorescent center is exemplified by silver in glass. The fluorescence properties of glass imparted by the silver atom under very definite conditions adds to the variety of interesting bulk and surface properties. In making fluorescent silver glasses both the formation of ions and the aggregation of atoms which cause non-fluorescence and finally yellow-coloration must be avoided.

Weyl obtains silver fluorescent glasses by the introduction of a high concentration of ions under strongly oxidizing conditions and subsequent reduction by hydrogen at temperatures so low (80-120° C.) that diffusion

*For Reviews of Parts I-III, see Glass Industry, Part I, *6*, p. 262 (1944), Part II, *9*, p. 405 (1944), Part III, *5*, p. 255 (1945), Part IV, *8*, p. 375 (1945), Part V, *9*, p. 450 (1946).

of silver atoms and, therefore, aggregation is negligible.

B. Cadmium Sulfide Glass. Isolated centers can also occur if two ions react with each other with such electronic deformation that their location may be considered a molecule within the glass. In a previous section it was shown that sulfide "molecules" can be assumed to exist in glass under such conditions. In this state they act in a manner similar to silver atoms and the glass fluorescence. Cadmium sulfide powder does not fluoresce, but by impregnating filter paper with a cadmium salt solution and treating with H_2S a subdivided form of fluorescent cadmium sulfide can be prepared. In yellow CdS filter glasses fluorescence and cut-off are affected adversely by iron and the fluorescence of a test of the melt is indicative of good cut-off performance.

C. Other Molecules. It deserves mentioning that among molecular centers causing fluorescence there are described in Weyl's monograph organic substances capable of existence in low melting glasses.

Fourth Class of Fluorescent Glasses: Glasses Containing Ionic Centers, "Fluorescent Glasses Proper"

A. Rare Earths. The protection of the excited electrons in the absorbing ions of rare earth character by stable outer shells isolates and, therefore, promotes the fluorescence mechanism analogous to the color of organic chromophors within protecting ring systems in organic dyes. The beautiful fluorescence of rare earths in pure (iron-free) glasses has attracted many workers. The defined structures of fluorescence have been used by Tomaschek for the interpretation of the vitreous condition of matter. The blue fluorescence of cerium, first discovered by Crookes, and the orange to red fluorescence of samarium and europium are noteworthy.

B. Manganese. A large part of the discussion of ionic fluorescence centers is devoted to manganese, which is the classical activator of fluorescent crystals and has been studied widely in glasses, too. The fluorescence is due to the presence of the divalent managanese ion (Mn^{++}), which is obtained substantially free from Mn^{+++} under reducing melting conditions.

The fluorescent light shows a sharp absorption band at 4250 A°, which may shift under the influence of the surrounding. The color variations from green to red have been applied not only to the production of fluorescent glasses but also to the study of the nature of this surrounding field—the nature of the constitution of the various base glasses themselves. The studies by Linwood and Weyl and by Kreidl, correlating the red fluorescence to a looser structure, are described.

C. Uranium. The fluorescence of uranium in glass has been known almost since Becquerel's discovery of fluorescence. It is attributed to the uranyl group $(UO_2)^{2+}$. The base glasses and reduction-oxidation equilibria favoring this group thus favor fluorescence, In very "basic" glasses containing much alkali, or lead uranate, groups are formed which do not fluoresce. In very "acidic" glasses containing many $(SiO_4)^{4-}$ groups and certain phosphate glasses the fourvalent uranous ion, U^{4+}, is formed which does not fluoresce either. In the same way strong reducing agents decrease fluorescence by causing some U^{4+} to be formed.

Rodriguez, Parmelee and Badger used the fluorescence of uranium to interpret the constitution of various base glasses by changes in the intensity of the fluorescent bands.

D. Copper. The fluorescence of copper in glass is discussed in the group of ionic fluorescence centers, because Cu^{+} and not elemental Cu° is believed to be the source of fluorescence. This fact is not established with certainty and possibly both Cu^{+} and Cu° participate in the process.

The temperature changes of the fluorescence of copper glasses was used by Rodriguez, Parmelee and Badger, for a study of constitutional problems.

E. Thallium. The fluorescence of thallium glass is based on Tl^{+} as a fluorescence center. As a consequence of the studies of H. S. Hood and other workers, two interesting uses of thallium glasses have been found: (1) The increase of the photochemical activation of mercury lamps by the conversion of absorbed 2537 A° into emitted 2900-4200 A° radiation. (2) The increase of the fluorescence of manganese by converting short wave to the long wave UV to which manganese responds.

F. Tin. Not only metallic tin but also the stannous ion can impart fluorescence to glass. The fluorescence ranges from the near UV to the blue-green. The UV emission can be utilized by adding manganese to the batch.

Tin-activated silica glass was described by Maddock. W. Kaufmann and collaborators invented complex alumo- and alumoboro-phosphate glasses containing tin oxide, reduced by urea, as an activator. H. Hood developed fluorine opal glasses containing stannous ions, which combine opalescence and fluorescence.

G. Lead. As a minor addition, lead excited by short wave UV, causes brilliant blue fluorescence which loses intensity as the lead concentration increases. Kreidl used a sterilizing lamp to identify more than a dozen optical glasses by the fluorescence color based on their lead content.

H. Vanadium. Vanadium glasses fluoresce yellow. Weyl found that the pentavalent ion is responsible for this fluorescence.

Uses of Fluorescence

A final chapter discusses the applications of fluorescent glass. Emphasis is laid on the following uses: (1) Study of the constitution of glasses by the interpretation of changes in fluorescence color. (2) Identification of glasses. (3) Determination of the vitrification temperature of a glass batch. (4) Illumination.

The determination of the vitrification of batches is based upon the fact that uranium fluoresces in the glass, while the raw materials, sodium uranate and uranium oxide, do not fluoresce.

Concerning application to illumination problems it is important to note that many glasses which do not fluoresce in the analytical UV lamp exhibit brilliant fluorescence when used as gas discharge tubes. Under those conditions, iron-free glasses containing arsenic, antimony, bismuth, thorium, lanthenum, columbium and many more metallic elements fluoresce.

Fundamentals of Solarization

Many glasses change their color in sunlight. The

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CHECKING THE THERMAL EXPANSION OF GLASSES AND METALS BY STRESS-OPTICAL TESTS*

By A. A. PADMOS

Summary

A method is described which is the result of many years' experience and is applied as a daily stress-optical check on glasses and metals for their thermal expansion.

The stress test applied for the purpose allows of accurate measurements with simple means and unskilled labor, which measurements may, in many cases, be considered equivalent to measurements of the coefficient of expansion with a degree of accuracy of $\pm 0.15 \times 10^{-7}$. In addition, the measuring procedure is considerably quicker than that of the measurements of the coefficient of expansion, so that the method is practically applied for testing the measure of adaptability of all the materials in our works that have to be sealed to glass, as well as for checking the matching of the glasses.

Introduction

If glass-glass joints or glass-metal joints constitute part of the manufacturing process in an industrial undertaking, and these joints are exposed to occasionally considerable differences of temperature in the subsequent manufacturing stages or in actual practice later on, a regular check on the thermal expansion of the glasses and metals used is necessary so as to minimize the amount of production shrinkage and breakage, when the product is in actual operation, resulting from deviations in the properties of the glasses or metals. First and foremost we have in mind the manufacture of incandescent lamps, gas-discharge lamps, wireless transmitting and receiving valves, X-ray tubes, and the like.

We may apply either of the following two methods: a) The direct measurement of the linear coefficient of expansion on the lines of one of the many methods recorded in literature. b) The measurement of the stress occurring between the two materials to be joined owing to a difference in coefficients of expansion, or the measurement of the stress engendered by sealing the two metals to be tested to a so-called standard material.

The following exposition will show that we have preferred the latter method.

Exposition

A. The coefficient of expansion. After we have sealed a glass to a metal and allowed the joint time to cool down sufficiently slowly, stresses will only have been left behind at the surface of the joint after cooling if the coefficients of expansion of the two materials differ.

As long as the glass is still soft there will not be stresses in it under the conditions mentioned. Stresses appear as soon as the temperature has fallen so far that the glass is only deformed elastically and not as a viscous liquid, owing to the difference of thermal contraction of the two materials.

Fig. 1 shows the expansion curves of two materials, viz.

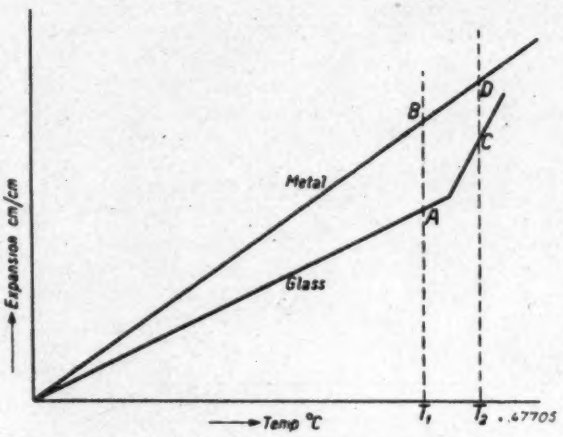


Fig. 1. Expansion curves of glass and metal.

of glass and of metal. If the glass solidifies at the temperature T_2 whilst cooling down, a difference of expansion (properly speaking, a difference of contraction) causes the beginning of a stress to arise as from that temperature, whereas if T_1 is the temperature of solidification a stress does not form until after that moment.

In the former case the difference of coefficients of expansion from room temperature to temperature T_2 is decisive for the amount of stress present at room temperature. In the latter case, however, it is the difference measured along the temperature range from room temperature to T_1. The ratio $DC : AB$ is the ratio of the amounts of stress in the two cases.[1]

From this it appears that it is essential to know not only the expansion curves of the material to be joined but also the location of T_1 or T_2 of the glasses in hand.

Similar factors apply for glass-glass joints. In this case the formation of stresses during effective cooling starts at the moment when *both* glasses have solidified.

Summarizing, we see that two things are required: a) A knowledge of the trend of the expansion according to the temperature. b) A knowledge of the temperature at which solidification of the glass(es) employed takes place.

Summarizing, we may formulate this as the knowledge of the difference of expansion between room temperature and the temperature of solidification referred to.

To come to an effective material test we proceed as follows.

There are a certain number of types of joint. Working on the experience gained with these joints in practice, we determine for each separate type of joint what differences of expansion are still admissible and what differences of expansion will sooner or later produce cracked glass. This requires accurate observation for a long time, but it gives us an insight into what materials are serviceable or not. It is difficult to submit general figures, the admissible differences being too closely linked up with the sealing-technique applied, the conditions of use, and the like.

*Reprinted from Philips Technical Review, Philips Research Laboratory.

[1] For the sake of simplicity we speak of accurately fixed temperatures T_1 and T_2. In reality, however, we have to do with longer or shorter ranges of temperature.

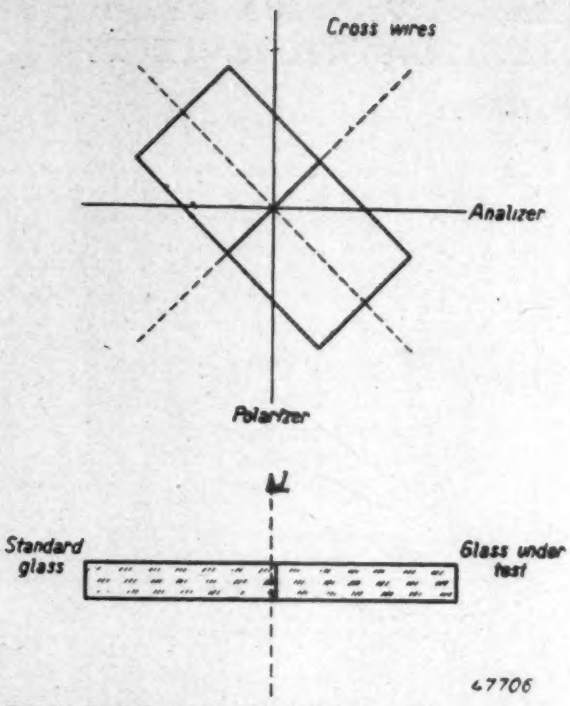


Fig. 2. Method of testing glass plates.

This is one of the reasons why the problem under discussion cannot be tackled in a much more exact way. On the face of it, it seems that from the difference of coefficients of expansion referred to, from our knowledge of the moduli of elasticity of the materials, and from our knowledge of the stress distribution in a given joint, we might decide from calculation whether the critical tensile strength of the glass is being exceeded in a given case. However, for various reasons this is well-nigh impossible in almost all cases. These reasons are:

a) The shape of the joint is usually such that a calculation of the stress distribution is out of the question in the majority of cases.
b) The fluctuations of temperature presenting themselves during the further treatment or in practice later on are so poorly defined that little, if any, knowledge can be derived from them about the stresses they bring about, stresses which, together with the stresses already present may lead to breakage.
c) The tensile strength of glass, is, in itself, a value difficult of determination, it being largely dependent e.g. on the nature of the surface and limiting planes, as well as on the duration of the forces present.

For all these reasons we can only avail ourselves of an arbitrary measure giving us quantitative information about the matching of the two materials, the use of this measure necessitating a procedure as described above.

However, if it is only a question of the measure mentioned in the previous section we have quite a different method at our disposal, viz.:

B. The stress test. Stress-testing, serving to find out the measure of adaptation of two glasses to one another, was first carried out in our concern by Ir J. Smelt of our glass-works. He started from the survey by F. Späte (Glast. Ber. 2, 1-19, 1924). His investigations were an inducement to work out a method for testing glasses and metals which has been in general use here these eight years and gives us a perfect insight into the location of the materials in reference to one another.

We shall first deal with the fundamentals of the method, reserving the description of the practical test for the next section.

It is well known that stress in glass can be determined and measured by the aid of polarized light. This is because glass without stresses is an optically isotropic material, becoming anisotropic if stresses appear.[2] According to classical optics an incident ray is then generally refracted, and two polarized rays, with their planes of polarization perpendicular in reference one to another, travel with slightly different velocities in the medium. After passing through a nicol these rays produce interference phenomena from which the phase difference arising between the two rays in the anisotropic medium may be determined quantitatively. This phase difference is proportional to the path the rays have covered in the medium and to the amount of stress in the glass. Which of the two rays is retarded depends upon the fact whether we have to do with compression or tension.

The degree of retardation is expressed in millimicrons per cm of the path covered through the medium.

So if we seal two materials together in a suitable shape and next determine the stress in $m\mu$/cm after properly cooling down, we have likewise a measure as mentioned above.

This method has the following advantages as compared with a check by means of measurements of the expansion:

a) The measurement requires accuracy, but no appreciable amount of experience of the operator.
b) The precautions necessary for measuring the coefficient of expansion properly, so as to avoid incorrect readings of the temperature, are redundant in the present case, while, besides, other precautions demand a much smaller amount of attention.
c) The knowledge of the temperature of solidification of the glass required when measuring the expansion is unnecessary here, since the measurement of the stress combines the two factors determining the stress.
d) The rate of measurement is much greater for different samples to be tested simultaneously, the time required for the measurement and its preliminaries being short (see under the practical test).
e) During this test both the glass and the metal are subjected to a treatment similar to that in practice later on, so that any changes in coefficient of expansion owing to that treatment are already embodied in the measuring results.

The Stress Measurement Procedure

In industrial undertakings as referred to in the introduction a number of kinds of glass and kinds of metal are made into joints. The tests comprise three categories of materials: a) the glasses; b) the metals; c) the glazes which melt at a low temperature and are used in sealing two glass bodies together.

The procedure is not identical for all three categories, though one and the same collection of so-called standard glasses is in use for all three.

(*Continued on page 476*)

[2]We restrict ourselves to simple stresses in the present case.

RECENT TRANSLATIONS OF RUSSIAN PAPERS OF INTEREST TO THE GLASS INDUSTRY

The originals of two papers, which appeared in the Russian journal, *Glass and Ceramic Industry*.

Continuous Production of Granulated Sodium Silicate

The process invented by N. A. Dodonov (*Stekolnaya i Keramicheskaya Promyshlennost*, Glass and Ceramic Industry, 1946, No. 11/12, p. 13) is illustrated by Fig. 1. Its left hand part shows the elevation of the feeder arrangement, and its right hand part, a cross-section of it.

The feeder is attached to an old Siemens tank of 28 sq. meters area. A refractory brick is removed from the wall of the tank. The molten silicate which flows through this hole is received by a refractory block in the upper part of which a conical groove is cut out; this groove is at the top 20 cm. x 10 cm. (8 in. x 4 in.) and is 4 cm. (1.6 in.) deep. The block can be exchanged easily for another similar block. From the groove, molten silicate flows into an inclined iron trough, the lower part of which rests on a brick column and the upper part is supported by a metal structure. In the moment when the silicate stream reaches the trough it is cooled by water streams.

Water is forced under a pressure not below 3 atm. (42 lb./sq.in.) through a 37 mm. (1.5 in.) vertical pipe (2) which ends in five parallel pipes, each 12 mm. (0.5 in.) in diameter, inclined roughly parallel to the iron trough. Water issues from these pipes in jets 1-1.5 m. (3-4½ ft.) long and reaches the trough in the same spot as the molten silicate.

In this manner the silicate solidifies to granules 0.3-2.0 mm. (0.012-0.08 in.) in diameter. The mixture of granules and water flows down the trough into wire baskets placed on trolleys (3). Water runs through the basket and into the sink (4). The trolleys carry the baskets filled with silicate granules to the storage room.

The granules contain about 5 per cent water. They are more easily soluble in water than big lumps of dry sodium silicate. No autoclaving is required for producing water glass from the granules. Granules are stirred with hot water in a kettle heated by steam or direct fire and form water glass of the desired consistency.

The silicate made by Dodonov contained 2.80 molecules of SiO_2 per 1 molecule of Na_2O. About 400 tons of granulated sodium silicate was produced within 7 weeks of work.

Acceleration of the Withdrawal of Glass in Foureault Furnaces

This problem is discussed by D. L. Gik in *Stekolnaya i Keramicheskaya Promyshlennost* (Glass and Ceramic Industry), 1946, No. 11/12, p. 2.

The distance from the slit of the debiteuse to the cutting machine of Russian Fourcault plants is 7 meters (23 feet). At a speed of withdrawal of 60 meters per hour (39 in. per min.) this distance is covered in 7 minutes, and at the rate of 90 meters per hour (59 in. per min.) in 4.6 min. The temperature of the sheet drops between the debiteuse and the cutter by about 850-900°C (1530-1620°F). This means that, at the higher rate of withdrawal, the glass on the average cools 190°C per minute and the average temperature gradient in the sheet is 125°C per meter.

Such rates of cooling and such gradients are dangerous within the annealing range but can with safety be much exceeded above and below it. The actual temperature gradient is, of course, not identical with the average gradient; along the first meter the temperature falls usually by 460°C, along the second meter by 120°, along the third meter by 110°, and along the fourth by 70°.

The cooling, before the annealing range is reached, should be even more accelerated: the first 30-40 cm. (12-16 in.) of the sheet should be more forcibly cooled. (The cooling should preferably be carried out in two stages, one cooler being placed above the other with a space be-

(*Continued on page* 491)

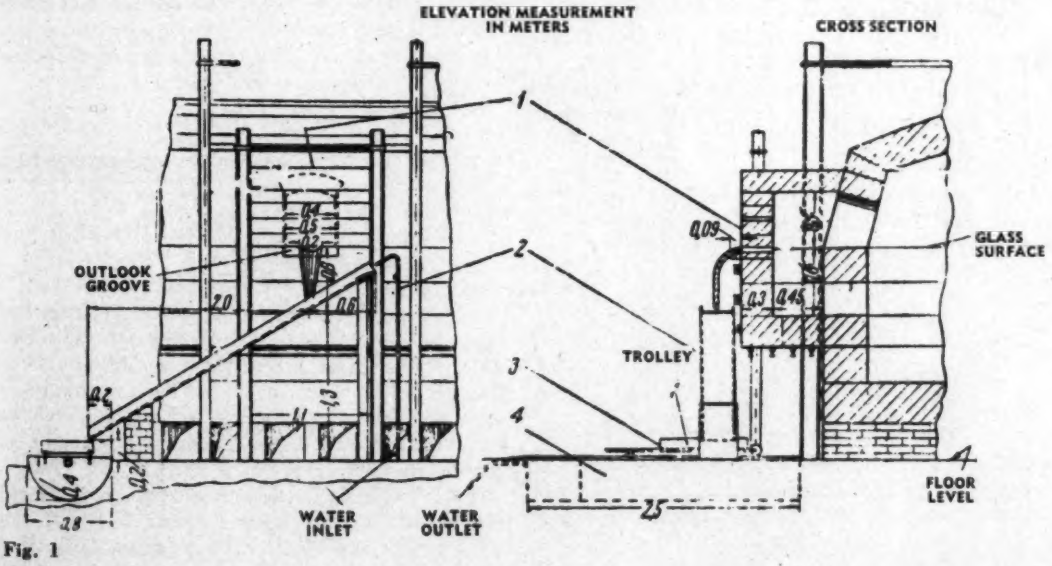


Fig. 1

INVENTIONS AND INVENTORS

A Summary of Recently Issued Patents of Interest to the Glass Industry

Glass Compositions

Eastman Kodak Glass. Fig. 1, Patent No. 2,425,403. This patent relates to an optical glass having an index of refraction for the D line (n_D) in the region above 1.7 and an Abbe value (v) between 24 and 28. Figure 1 shows at the top a diagram of the ingredients used in this glass and at the bottom a diagram of the optical properties of the glass. This glass is the invention of Kuan-Han Sun who assigned it to Eastman Kodak Company.

It has been known that germanium oxide can be used to make glass but the optical properties of such a glass were discovered by this inventor. In the upper figure, a ternary diagram shows the limits of glass formation in weight and mole per cent, although the boundary lines are not exact.

Six examples are given of the general formula, as follows, in which W represents weight and M represents molar proportions:

Example No.	KF W	KF M	NaF W	NaF M	TiO_2 W	TiO_2 M	GeO_2 W	GeO_2 M	n_D	μ	n_F-n_C
1	..	...	15	29.0	20	20.4	65	50.6	1.7521	26.6	0.02831
2	..	...	21	38.0	21	20.0	58	42.0	1.7198	26.7	.02692
3	21	30.4	..	...	23	24.3	56	45.1	1.7176	26.5	.02705
4	..	...	30	48.5	30	25.5	40	26.0	1.7085	24.6	.02880
5	..	...	20	37.5	10	9.8	70	52.7	1.6681	33.3	.02009
6	..	...	10	21.7	..	...	90	78.3	1.6530	41.9	.01559

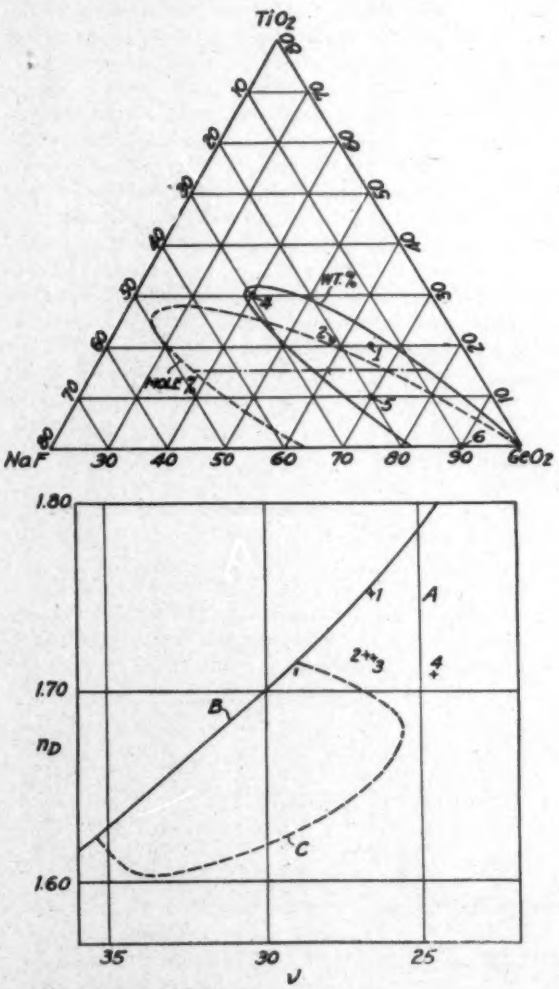


Fig. 1. Eastman Kodak Glass.

The most useful glass is formed in the limited area of the dotted line.

In the lower part of the figure, the area A shows the optical properties of this new glass, the line B shows commercial flint glass and the area C the field of fluosilicate glass.

The patent gives complete directions for making glass according to this invention. Apparently no references were cited by the Patent Office during the prosecution of the application.

Miscellaneous Processes

Method of Forming Glass Film on Metal. Fig. 2, Patent No. 2,424,353. This patent relates particularly to the manufacture of television tubes but it would seem to be of possible use in depositing a glass film on any metallic support. It is the invention of Sanford F. Essig of Fort Wayne, Ind., who assigned it to Farnsworth Television and Radio Corporation.

The patent gives in detail the reasons for the use of tubes having a thin glass film but the particular point of interest is the manner in which the glass is applied to the metal. This is done by first applying glass to the metal and then covering the glass with a metallic foil. This body is then heated until the glass becomes plastic and then pressure is applied so that the glass is spread out into a very thin film in intimate contact with the metal. The foil is then removed to leave a very thin coating of glass on the metal. Other methods are described for carrying out this general idea.

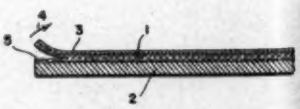


Fig. 2. Method of Forming Glass Film on Metal.

Fig. 2 shows a glass layer 1 between a metal base 2 and a metallic foil 3. Both of these are preferably made of silver. The silver foil is about 0.001 in. in thickness. The base 2 is heated before applying the glass. While suitably heated, the sandwich is passed between rollers which thin out the glass and press the layers into intimate contact. The foil is then removed as shown by the arrow 4, taking with it about one-half of the layer of glass, leaving a thin layer 5 firmly attached to the metal base 2. The use of a metal foil for this purpose seems to be new with this inventor.

The following references are of record in the file of this patent: United States Patents: 2,178,402, Miller, Oct. 31, 1939, and 1,300,397, Holmstrom, April 15, 1919.

Enamel Composition. Fig. 3, Patent No. 2,425,032. This invention relates particularly to an enamel suitable for use in the manufacture of wire-wound electrical resistors but presumably the same composition might be useful for other purposes. It is an invention of Alden J. Deyrup of Westfield, N. J., who assigned it to E. I. du Pont de Nemours & Company of Wilmington, Del. Resistors of this type comprise a ceramic tube on which the wire is wound together with such metallic clips as are necessary. This assembly is then coated with a vitreous enamel to give strength and insulation. This patent is a continuation-in-part of an application by the same inventor filed November 29, 1943.

In the use of devices of this kind, severe strains are set up by the heat developed in the wire as well as by mechanical stresses. Deyrup's Patent No. 2,351,252 shows an enamel for this purpose which is very satisfactory but which requires a core of steatite porcelain for best results but this material is hard to obtain. The present invention provides an enamel which can be used with a supporting tube of steatite porcelain, magnesium aluminum silicate and magnesium silicate.

In Fig. 3 a ceramic refractory base is shown at 1 carrying the resistance wire 2. This wire is connected to tabs 3 and 4 to which the electrical connections may be made. The coating of this new enamel is shown at 9.

Eight examples of batch compositions suitable to secure the improved enamel are given in the following table, all percentages being given by weight, based on the total weight of the batch:

Constituent	Batch							
	A	B	C	D	E	F	G	H
Read Lead (Pb_3O_4)	23.8	32.4	28.6	23.8	24.1	30.5	31.0	15.9
Zinc Oxide (ZnO)	11.8	5.7	9.5	11.9	12.0	7.6	7.8	19.8
Boric Acid (H_3BO_3)	35.6	34.5	34.5	35.7	36.3	34.5	35.1	35.7
Flint (SiO_2)	8.0	10.2	10.2	7.9	8.0	10.2	10.6	7.9
Kaolin (39.5% Al_2O_3; 46.5% SiO_2)	19.2	15.6	15.6	16.1	16.1	15.6	15.5	15.9
Cobalt Oxide (Co_3O_4)	1.6	1.6	1.6	1.5	1.6	1.6	...	1.6
Sodium Zirconium Silicate (14% Na_2O; 29% SiO_2; 55% ZrO_2)	...	...	...	3.1	...	...	...	3.2
Ammonium Phosphate ($NH_4H_2PO_4$)	...	...	...	...	1.9	...	...	...

The batch is prepared in about the usual way and the melt may be applied to the assembly by dipping or otherwise.

The patent contains 12 claims and the following references are of record in the application file: United States Patents: 1,938,674, Terwilliger, Dec. 12, 1933; 2,351,252, Deyrup, June 13, 1944; 441,514, Valere, Nov. 25, 1890; 634,117, Lutwyche et al., Oct. 3, 1899; 863,293, Leonard, Aug. 13, 1907; 1,842,433, Terwilliger, Jan. 26, 1932; 2,179,212, Ganci, Nov. 7, 1939; and 2,357,473, Jira, Sept. 5, 1944. Foreign Patents: 233,295, Great Britain, 1925. Other References: Technologic Papers of the Bureau of Standards, No. 246 (1923), page 715.

Ampule Cutter. Fig. 4, Patent No. 2,425,093. This patent shows a device to enable physicians and others to readily open glass ampules. It is the invention of David W. Fosler of Indianapolis, Ind. It is well known that the users of medicants in glass ampules need some quick and easy way to open them. Also the instrument must be capable of complete sterilization.

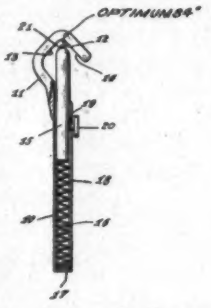


Fig. 4. Ampule Cutter.

Two forms of the invention are shown in the patent. Fig. 4 shows the form adapted for holding in the hand while another figure of the patent shows a form to be attached to the wall. The device comprises a body 10 having an attached hook 11. The angle between the walls of the hook are preferably 84 degrees. A plunger 15 in the body 10 is urged upwardly by a spring 16. A diamond 21 is mounted on the top of the plunger and a thumb button 20 provides means for retracting the plunger.

In use, the neck of the ampule is inserted in the hook 11 while the plunger is withdrawn. The ampule is then turned so that the diamond makes a clean scratch around the neck which then may be readily broken off. This patent is supposed to be an improvement over a patent to Francisco Foz Bello, No. 1,584,572, for reasons which will be apparent. The following references are of record in the file of this patent: United States Patents: 1,584,572, Bello, May 11, 1926; 531,051, Marquart, Dec. 18, 1894; 364,835, Maloy, June 14, 1887; and 818,682, Gibson, Apr. 24, 1906. Foreign Patents: 21,995, Germany, May 8, 1926.

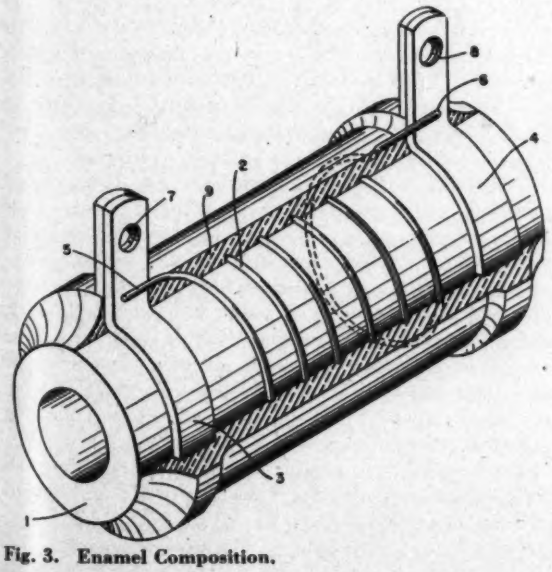


Fig. 3. Enamel Composition.

Plastic Refractory. Patent No. 2,425,152. This patent provides a plastic refractory particularly useful in making or patching linings of the walls of kilns and furnaces.

(*Continued on page* 488)

Research Digest

Infrared Absorption Spectra of Some Experimental Glasses Containing Rare Earth and Other Oxides

In connection with experiments upon glass spectral filters and upon the physical properties of certain other glasses as a function of their composition, Stair and Faick have measured the infrared transmissions of a number of soda-lime-silica glasses containing some rare earth and other coloring oxides. This work is reported in the January 1947 issue of the *Journal of Research* of the National Bureau of Standards.

All of the glasses used in this investigation were of the same basic composition; namely, SiO_2, 71.4%; CaO, 10.2%; and Na_2O, 18.4% as computed from the batch composition. Calcium and anhydrons sodium carbonate of reagent quality and powdered crystalline quartz were used in the base glass, the other materials being added in the form of oxides.

The rare earth oxides used were from the recently acquired James collection and have been analyzed for impurities. The praseodymium oxide contained small amounts of lanthanium and yttrium in addition to traces of calcium, copper, iron, magnesium and silicon. The neodymium oxide was of high purity, containing only traces of calcium, copper, iron, magnesium and silicon. The samarium oxide was especially good, containing, in addition to small amounts of calcium and silicon, only traces of magnesium and lead with praseodymium doubtful. The gadolinium oxide contained about 10% of europium, about 1% each of bismuth and magnesium, in addition to a small amount of calcium, traces of erbium, silicon and samarium, and possibly traces of potassium and lead. The erbium oxide, while not subjected to a thorough spectrochemical study, contained about 1% yttrium, smaller amounts of holmium and thulium, and traces of scandium and ytterbium. The purity of the yttrium oxide was not known.

An examination of the different absorption curves shows no significant bands for yttrium or for europium, nor the presence of overlapping of absorption bands that might be expected in mixed materials where the same impurities are present for a number of the glasses. Hence, these impurities were in very small amount or else of a type that is known to produce relatively weak absorption within the region 0.7 to 4.5 μ.

The glasses were melted in a 25-ml platinum crucible in a platinum resistance furnace. The samples obtained often contained a few seeds and a small amount of striation which may have caused small errors in absorption measurements. However, as the complete infrared absorption curve was obtained through the same area of the sample, relative values between the different wavelengths should be adequate.

The spectroradiometer used consisted of a mirror spectrometer with mirrors 50 cm in focal length. A small fluorite prism on a Wadsworth mounting was employed. The observations were made by the "point by point" method. A portable vacuum thermopile of bismuth-silver, connected with an iron-clad Thomson galvanometer, was used for measuring the radiation. The source of the radiation was a Nernst glower, focused upon the entrance slit of the spectrometer by means of a large concave mirror of 1-m focal length. The galvanometer readings were read visually and recorded. The sample was placed in front of the entrance slit of the spectrometer by means of a mechanical carriage which placed it in the same position for each wavelength. The effective spectral slit width varied from about 0.17 at 2 to 0.07 at 4.5 μ.

The base glass (SiO_2, 71.4%; Na_2O, 18.4%; and CaO, 10.2%) showed no absorption bands at wavelengths shorter than about 2.8 μ. Beyond this wavelength, the silica absorption increases rapidly with increase in wavelength. (All glasses having a silica base show a high absorption in the region of 2.8 to 4.5 μ, which is caused by some combination of silica with water and other base materials of which the glass is composed.)

No appreciable absorption in the near infrared is caused by yttrium oxide (Y_2O_3) when added in an amount of 10 per cent (glass thickness, 6.81 mm). Neither was any absorption observed within the visible spectrum. A comparison of the curve for yttrium oxide glass with those for the base glass and the erbium and gadolinium oxide glasses indicates the possibility of some general absorption in the region of 2.7 to 4.2 μ. However, differences in thickness and amounts of water within the glass may account for the greater absorption in this region.

Two strong absorption maxima occur at about 1.45 and 1.90 μ as the result of the addition of praseodymium (Pr_6O_{11}) in the amount of 10 per cent. Weak bands occur at about 0.76 and 1.0 μ. The general shape of the transmission curve indicates the possibility of additional bands in the region of 2.4 and 4.0 μ. Absorption in the visible spectrum gives this glass a light yellowish green color.

The addition of neodymium (Nd_2O_3) in the amount of 10 per cent results in three strong absorption bands at about 0.77, 1.63 and 2.43 μ. It is to be expected that this material would produce a number of absorption bands in the near infrared, judging from the number and intensity of the bands in the visible spectrum.

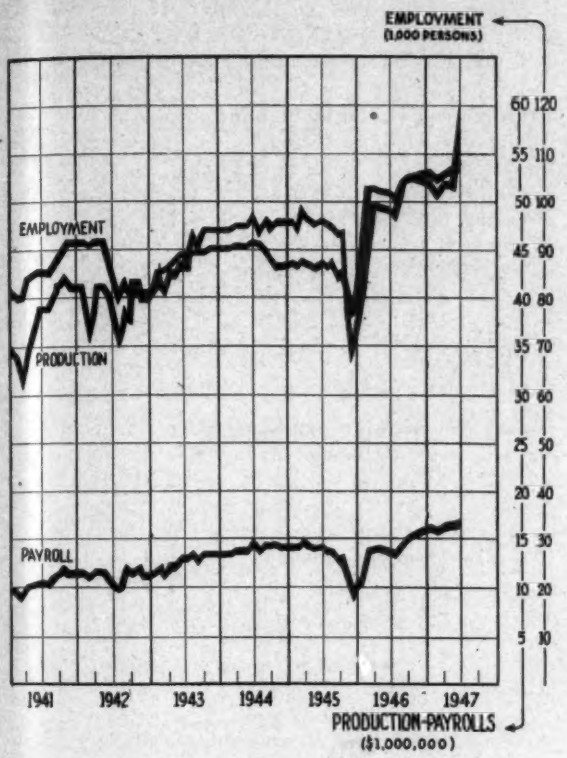
The addition of samarium oxide (Sm_2O_3) in an amount of 10 per cent gives rise to a very strong absorption band at about 1.47 μ, and weaker bands at about 1.1, 1.92, 2.62 and 4.1 μ. The strong band at 1.47 μ almost completely masks the one in the neighborhood of 1.1 μ. The presence of so many bands within this part of the infrared spectrum suggests the possibility of other bands at longer wavelengths. Hence, it would be interesting to study this material incorporated into a special infrared transmitting glass. Absorption in the visible spectrum gives this glass a light yellowish hue.

No appreciable absorption occurs in the near infrared (or in the visible spectrum) because of the addition of gadolinium oxide (Gd_2O_3).

(*Continued on page* 490)

CURRENT STATISTICAL POSITION OF GLASS

THE GLASS INDUSTRY'S INDEX



During the month of June 1947, activity in the glass industry increased a little more than 2 per cent. The June figure is an estimated $59,000,000, as compared with $58,000,000 reported for the previous month. Production during June 1946 was an estimated $48,800,000, which is about 20 per cent below June this year. Total production for the first half of 1947 is an estimated $343,500,000, as compared with $283,800,000 produced during the same period in 1946.

Employment and payrolls: In its detailed report on employment for the month of June 1947, the Bureau of Labor Statistics has issued a new series of production-worker estimates which have been adjusted to the 1945 bench-mark data from the Bureau of Employment Security of the Social Security Administration. This new data corrects the downward bias which has accumulated since 1939. Hence, current figures of employment are considerably higher than those given through May 1947.

Based on the upward adjustment, the number of persons employed during the month of June 1947 were 120,000. This is a decrease from the 122,000 persons (also an adjusted figure) employed during May. The June 1946 employment figure was 119,000 persons.

Payrolls for June 1947 rose about 2 per cent to an approximate $16,500,000. The May figure was $16,250,000. During June 1946, payrolls were $13,300,000. Estimated payrolls at the close of the first half of 1947 have reached a total of $96,500,000 as compared with $67,200,000 paid out by glass manufacturers during the corresponding period in 1946.

Glass container production, based on figures released by the Bureau of Census, continued to drop for the month of July. The figure reported is 8,840,014 gross, which is about 8 per cent below the 9,619,496 gross produced during June. During July 1946, production was 9,604,432 gross, which is about 7 per cent above production for July this year. July production is the lowest monthly figure reported thus far in 1947. Glass container production has totalled 70,397,685 gross for the first seven months of 1947.

Shipments for July 1947 also fell off to the lowest monthly figure for the year. Shipments were 8,581,079 gross as compared with 8,821,025 gross shipped during

GLASS CONTAINER PRODUCTION AND INVENTORY

(All figures in gross)

		Production July 1947	*Stocks July 1947*
Foods; Medicinal & Health Supplies; Chemicals, Household, Industrials; Toiletries & Cosmetics	Narrow Neck	2,632,886	3,263,554
	Wide Mouth	2,030,079	1,885,983
Dairy Products		330,775	222,143
Home Canning		*266,675	381,239
Beverages, Returnable		1,225,494	497,557
Beverages, Non-returnable		.....	.....
Beer, Returnable		865,904	274,666
Beer, Non-returnable		765,189	145,212
Liquors		447,125	200,108
Wines		161,123	129,583
Packers' Tumblers		114,764	60,036
Total		8,840,014	7,060,081

*This figure represents Fruit Jars only.

GLASS CONTAINER SHIPMENTS

(All figures in gross)

	July 1947
Narrow Neck Containers	
Foods	763,596
Medicinal & Health Supplies	846,560
Chemical, Household & Industrials	347,397
Beverages, Returnable	1,118,775
Beverages, Non-returnable	.....
Beer, Returnable	577,190
Beer, Non-returnable	686,235
Liquors	439,386
Wines	135,740
Toiletries & Cosmetics	320,635
Sub-Total (Narrow)	5,235,514
Wide Mouth Containers	
Foods	1,640,521
Dairy Products	308,105
Home Canning	464,031
Medicinal & Health Supplies	187,971
Chemical, Household, Industrials	49,533
Toiletries & Cosmetics	97,878
Packers' Tumblers	113,806
Sub-Total (Wide)	2,861,845
Total Domestic	8,097,359
Export Shipments	483,720
Total Shipments	8,581,079

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June. This is a difference of about 2 per cent. Shipments during July 1946 were 9,232,410 gross, which is about 7 per cent greater than for July 1947. Total shipments made thus far in 1947 are 66,797,711 gross. During the same period in 1946, 65,820,783 gross were shipped.

Stocks on hand at the close of July 1947 were 7,060,081 gross, as compared with 6,854,105 gross at the close of June and 4,089,662 gross at the close of July 1946.

Plate glass production for the month of July 1947 continued to fall, according to the Hughes Statistical Bureau. The July figure is 17,670,240 sq. ft. produced as compared with 21,025,871 sq. ft. produced during the preceding month. This represents a decrease of about 15 per cent. Plate glass production during July 1946 was 18,408,556 sq. ft., or about 4 per cent above July this year. Total plate glass production for the first seven months of 1947 is 148,138,879 sq. ft., as compared with 109,598,633 sq. ft. producing during the corresponding period in 1946.

Automatic tumbler production fell off about 19½ per cent during the month of July 1947. Production was 4,993,181 dozens as compared with 6,210,357 dozens produced during the preceding month. Production during July 1946 was 6,070,128 dozens. Shipments for July 1947 also dropped—about 17 per cent—to 4,346,071 dozens. The June figure was 5,260,775 dozens. Shipments for July 1946 were 5,984,036 dozens. Stocks on hand rose slightly from 7,728,845 dozens at the close of June to 7,775,388 dozens at the close of July. Stocks on hand at the close of July 1946 were 4,997,007 dozens.

Table, kitchen and household glassware: Manufacturers' sales of machine-made table, kitchen and household glassware for the month of July 1947 were 2,301,641 dozens. This represents a drop of close to 31 per cent from June sales of 3,330,846 dozens. Sales during July 1946 were 3,553,057 dozens. Total manufacturers' sales during the 12-month period ending July 1947 were 41,807,551 dozens, as compared with 43,865,835 dozens sold during the corresponding period in 1946.

ARMSTRONG PLANS NEW LABORATORIES

Plans for the construction of new laboratories, comparing with the most modern and attractive industrial research and development facilities in the country, have been announced by Armstrong Cork Company.

Bids for the construction of the research facilities on a 40-acre site, three miles from Lancaster, will be asked late this fall. If bids are satisfactory as to cost, contracts will be let promptly and construction will be started as soon as possible. It is hoped that the planned new laboratory will be ready for use by the summer of 1949.

The main research building will be of two- and three-story construction. In addition to the main building, a large single-story Pilot Plant, several smaller Plants and a Boiler House will be built.

The company has also announced plans for additions to its general offices which would increase available office space about 30 per cent.

IFMA CONTEST FOR TECHNICAL PAPERS

The Industrial Furnace Manufacturers Association has announced the "IFMA Prize Contest" to promote the publication of more and better articles in the trade press describing the economic advantages obtained by the use of modern industrial furnaces, kilns and ovens. Papers published between October 1, 1947 and September 1, 1948 will be eligible for prizes.

The articles may be original or they may be technical society papers subsequently published in trade or technical papers. Competition in the contest is open to all individuals or groups with the single exception that they must not be connected with the industrial furnace, kiln or oven industry.

The papers will be judged as follows: Completeness and accuracy of operating data such as fuel or electricity costs, labor costs, floor space requirements, savings in preceding or subsequent operations, material costs, etc.; concise and complete coverage of improvements in the products, such as physical qualities, appearance, the reduction of rejects or rework, etc.; clearness and completeness of description of equipment, including size, construction, operating cycle, etc.; uniqueness of design with regard to method of operation, material handling, heating, etc.; completeness of description of parts treated, size, material, rate of production, etc.; and, in general, the ability for a possible user in the same or similar industry to apply these data to his product or operations and to determine the possible advantages from his use of the equipment or process.

The awards will consist of: First Prize, $1,000; Second Prize, $300; and Third Prize, $200. In addition, special non-cash awards will be made to the magazines publishing the three winning awards. Judges will be appointed by the Industrial Furnace Manufacturers Association and will be announced at a later date.

EMILY VAN SCHOICK APPOINTED LIBRARIAN AT ALFRED

Miss Emily C. Van Schoick, for more than 25 years associated with the American Ceramic Society in Columbus, Ohio, has been appointed to the newly-created position of librarian of the New York State College of Ceramics at Alfred University. She will assume her new duties Sept. 10, 1947.

In announcing the appointment, Dr. Samuel R. Scholes, dean of the college, said that the library this year will build up its collection of reference works, acquire additional foreign publications, increase the scope of its periodical subscriptions and enlarge its collection of books in collateral fields such as chemistry, physics and mineralogy. The library has a $10,000 fund for this work during the coming year.

Miss Van Schoick, who has had wide experience in editing ceramic abstracts and in recent years editing the Journal of the American Ceramic Society, is one of the few women who are fellows of ACS. She is a graduate of Illinois Wesleyan University.

• Owens-Corning Fiberglas Corporation is sponsoring a full-color film entitled "Watts in Glass," featuring the role of Fiberglas insulation in electrical equipment of many types.

BALL BROTHERS EL MONTE PLANT TO START PRODUCTION

Mr. Hugh Crawford, General Manager of Ball Brothers Pacific Coast division, has announced that the company's new El Monte, California, plant will begin operations on or around August 30. The initial daily output will be approximately 2,500 gross of food packers' ware and fruit jars.

Forming equipment to be used in this new operation will include the 5-section I.S. machine, Millers and a Lynch No. 16. Tank capacity is 150 tons. The El Monte plant will produce a complete line of wide-mouth and narrow-neck ware, particularly in classifications that are used widely by the packing, canning and preserving industry, in addition to the full line of Ball home canning jars. Wines are also expected to be a major item.

Hugh Crawford

Mr. Crawford stated, "It is likely that there will be a limited production at the outset of coffee jars, condiment bottles and proprietary bottles. Catsup bottles, both tall and stubby, also will be manufactured.

"We expect to specialize in containers for the food packing industry and, at the same time, make fruit jars for home canning. These containers will be made of the finest flint glass whose quality always has been characteristic of Ball-made glassware."

In addition to a wide line of packers' ware, a specialty product which will be made at El Monte will be the new glass Ball Freezer Jar, a container for frozen foods, for use in locker plants and in home freezer units.

Beside the extensive glass manufacturing operation, the plant includes complete facilities for the manufacture of both CT and lug type metal caps, thus supplementing also the closure manufacturing facilities of the Pacific Coast. The closure plant has been in operation for nearly five months and is turning out a full line of both plain and lithographed caps.

Some idea of the size of the operation is indicated by the fact that there is almost a mile of Southern Pacific rail siding wholly within the plant site. The glass factory proper is housed in a steel and concrete building 120 feet wide and 1,000 feet long. The cap plant is in a separate building of similar construction, 120 by 240 feet. When production gets fully under way, the operation is expected to employ 450 employees.

Executive personnel of Ball Brothers Company of California, Inc., includes Mr. Crawford as General Manager; P. Goetz, Sales Manager; Chester Peters, Plant Superintendent; and Harry Flach, Office Manager.

• William W. Wright, Jr., has been named General Manager of the Plaskon Division of Libbey-Owens-Ford Glass Company. For nearly two years, Mr. Knight has been assistant to D. H. Goodwillie, Executive Vice President of L-O-F. He has had 11 years' experience in chemical production with Wyandotte Chemicals Corporation and six years in war production work prior to joining L-O-F.

J. H. Wright F. T. Nesbitt

NEW LIBBEY GLASS MANAGER NAMED

The retirement of John H. Wright as Vice President of Owens-Illinois Glass Company and General Manager of Libbey Glass Division has recently been announced to become effective December 31. Succeeding Mr. Wright is Frank T. Nesbitt, also Vice President of Owens-Illinois.

Mr. Wright, associated with Libbey Glass for 43 years and its Manager since 1918, said he would devote more time to his personal interests. He has long been active in Toledo's civic and cultural affairs.

The retiring executive began his career with Libbey Glass Company in 1904. He subsequently served as its Assistant Treasurer, Sales Manager and Vice President. When Owens-Illinois acquired the Libbey Glass Company in 1936, Mr. Wright was appointed President of Libbey. In a reorganization later, Libbey became an Owens-Illinois division and he was named its General Manager and a Vice President of the parent company.

Mr. Nesbitt joined the Illinois Glass Company in 1917 and twenty years later was named a Vice President of Owens-Illinois Glass Company. In 1939, he became President of the Owens-Illinois Can Company, a post he held until Owens-Illinois sold its metal container business in 1944.

OWENS-ILLINOIS ACQUIRES AMERICAN COATING MILLS

W. E. Levis, Chairman of the Board of Owens-Illinois Glass Company, has announced the acquisition of American Coating Mills, Inc., producers of clay-coated folding cartons and carton board. The assets and business of the company were acquired for common shares of Owens-Illinois stock.

American Coating Mills, with plants in Elkhart and Chicago, will be operated as an independent division of Owens-Illinois and general offices of the division will be located in Elkhart. R. L. Snideman, former President and General Manager of American Coating Mills and newly elected Director and Vice President of Owens-Illinois, will be in charge of the division's activities.

American Coating Mills employs approximately 700 persons and has an annual sales volume in excess of $10,000,000.

GLASSMEN NAMED DIRECTORS OF CONTROLLERS INSTITUTE

Members of the glass industry who were elected Directors by the local controls of the Controllers Institute of America in their respective cities are George E. Myers, Ball Brothers Company; Floyd C. Barton, Hazel-Atlas Glass Company; Clarence P. Sullivan, Fostoria Glass Company; Stanley P. Jones, Northwestern Glass Company; and C. O. Dawson, Owens-Illinois Glass Company.

GERMAN WINDOW GLASS PRODUCTION

Raw Materials: The domestic supply of raw materials is sufficient. The great capacity of window glass tanks and the high viscosity of the melt, however, presuppose more than average quality of these materials.

The quality of sand has suffered because of the difficulties in procurement of labor, maintenance of equipment and allocation of coal and power. The average iron and alumina content of limestone and dolomite has increased for the same reasons. Because of the shortage of arsenic and selenium the color of window glass has become darker, although not in a detrimental way.

The greatest handicap is the variability of soda ash. The change from the desired coarseness to excessive fineness contributes to corrosion and causes inhomogeneities. The lack in soda ash threatens the necessity of restricted window production since the availability of alkali bearing substitutes is nearly exhausted.

Refractories: Extra quality material has deteriorated and special shapes have become unavailable. Consequently, the life of tanks has decreased and more time is lost in repair periods.

Fuel: The larger plants remain unaffected by the coal shortage since they are based on gas piped from central stations. Other plants were forced to idle.

Production: A. *British Zone.* The present production level has not been affected excessively by these shortcomings. The monthly production in the British and American zones, based on thickness of 2 mm, was about twenty million square feet. The use of a standard thickness of 2 mm (2.3 mm before the war) is but an adaptation to foreign usage which had been started during the war.

The window glass industry has achieved 80% of its full production level because of the use of rational methods, the exclusive consumption of native raw materials and the relative scarcity of war damages. In 1946 the three plants in North Rine-Westfalia (German Libbey Owens [Delog], Deutsche Tafelglas [Detag] and Rheinische Ziehglas [Rezag]) have reached a production of 140 million sq. ft. Their capacity is about 170 million sq. ft. The total demand in Germany amounts to about 250 million sq. ft. The present production volume thus may be called considerable.

B. *Other Zones.* In the U. S. A. zone the Weiden plant of Detag produces 3½ million sq. ft. per month. So does the Vopelium Wentzel plant in St. Ingbert-Saar in the French zone. In the Russian zone the raw material situation is much less favorable. Torgau produces about 2 million sq. ft. and the nationalized Kuenzel plant produces a small amount. Production increases are scheduled in the immediate future. No short range success is expected of the many attempts to revive the antiquated blow process.

The entire German window glass capacity is estimated to 25 million sq. ft. per month.

• R. Charan, Head of the Department of Glass Technology, College of Technology, Benares Hindu University, India, on a recent visit to the United States, visited several of our educational institutions in order to learn which courses are given in the fields of ceramics and glass technology. He also was interested in the equipment used in our research projects.

NEW EQUIPMENT AND SUPPLIES

NORTH AMERICAN DIAPHRAGM AIR MOTOR

The North American Mfg. Company, 4455 East 71st Street, Cleveland 5, Ohio, has announced the development of its Series 600 Diaphragm Air Motor. It is designed primarily for use with

The North American Adjustable Port Valves which have the adaptability feature necessary for straight-line flow control, but it can be used wherever the need for pneumatic control might arise.

Accepted pneumatic controller air pressures of 0 to 15 psi afford an impulse pressure range of 3 to 13 psi to the diaphragm motor which results in full travel of the motor arm, 26°, and develops 25 in.-lbs. torque for 1 lb. change in impulse pressure. These ratings are for the No. 600-65 size motor.

Provisions have been made on the diaphragm motor for a valve positioner to obtain the maximum in valve response accuracy. Mounting lugs are provided specifically for fastening to supports independent of the piping and it can be mounted in any position relative to the piping.

SORENSEN VOLTAGE REGULATOR

Sorensen & Company, Inc. Stamford, Conn., has announced a new Sorensen Voltage Regulator, Model E-3006, designed to provide a highly stable, precisely regulated source of DC voltage and current especially applicable for testing of instruments.

The unit measures approximately 3′ high x 2½′ wide x 18″ deep. Physically the unit is divided in half. The upper half is a modified Nobatron with the following qualifications: input voltage range, 95 to 125 volts AC; output voltage, 6 volts DC; load range, 7½ to 15 amps; regulation accuracy, 0.1%; ripple voltage RMS Max, ½%; recovery time, 0.2 seconds; input frequency range, 50 to 60 cycles; and ambient temperature range, —50°C to +50°C.

The lower half contains a regulated DC power supply with these characteristics: input voltage range, 90 to 135; output voltage, 0 to 300 volts DC continuously adjustable; load capacity, 100 milliamperes; regulation accuracy, 1/10 to 1%; and input frequency range, 50 to 60 cycles.

The input voltage of the regulated DC power supply has been made extremely stable and accurate through the use of a Sorensen Model 150 which controls the input line voltage. As a result, according to the announcement, the output is kept at its setting without variation.

TEMPERATURE MEASURING SYSTEM

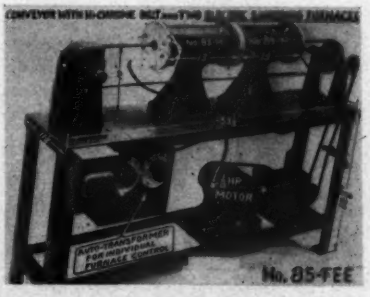
Fairchild Camera and Instrument Corporation, 88-06 Van Wyck Blvd., Jamaica 1, New York, has announced the new Fairchild Pneumatic Temperature Measuring System for measurement and control of extremely high gas temperatures to 5,000 degrees, Reaumur. The instrument is a form of gas thermometer utilizing the density of the gas being measured as a direct indication of the temperature.

It is stated that this method can solve specific gas measurement-control problems encountered in a broad variety of fields. The new system can be applied for temperature measurement and control wherever a small quantity of the high temperature gases to be measured or controlled can be continuously sampled.

Specified accuracies for these instruments are plus-or-minus 1% to 2,500 degrees R., and plus-or-minus 2% from 2,500 to 5,000 degrees R., with a response rate of ½ second or less.

EISLER ELECTRIC FURNACE

Eisler Engineering Company, Inc., Newark 3, New Jersey, has placed on the market a new heating unit which,



in connection with a preforming punch machine, can be economically used for continuous automatic mass production of synthetic beads or glass buttons from powdered glass.

The unit consists of a fabricated oblong steel table upon which two tubular electrically-heated furnaces and an endless Nichrome conveyor belt are mounted. The belt, when moved, passes slowly through the center bores of the furnaces. The conveyor belt is driven by a ⅛ H.P. electric motor, 1725 R.P.M., over a speed reducer and chain transmission. Motor and speed reducer are bolted on steel bases welded upon the lengthy bars underneath the table.

The sintering operation in the furnaces takes place after preliminary processing work is done on a glass bead punch machine. The powdered or granulated material is filled into the feeding hopper of this machine and automatically mixed, measured and pressed to the desired shape and size by means of proper dies and punches. The bonded beads dropping thereafter from the chute of the press upon the conveyor belt are slowly carried through the electric furnaces wherein the volatile matter of the binding material is expelled and the bead particles coalesce into a homogeneously body, shaped at any required temperature up to 1800°F. The finished beads or buttons are automatically discharged.

Production of the unit combined with a rotary type glass bead machine is about 200 to 300 pieces per minute.

CATALOGUES RECEIVED

Surface Combustion Corporation, Toledo, Ohio, has announced the publication of an eight-page booklet entitled "Humidity Control is more important in your plant than you may realize," which explains the principle of operation and details of application of the Kathabar System of Selective Humidity Control for industrial processing applications.

The booklet shows the various methods that are commonly used in dehumidification compared with the direct-cycle of selective dehumidification-humidification provided by the Kathabar System.

The flexibility of the operation is illustrated by a chart giving the various temperature-humidity conditions available from the system as it might be applied to one large processing plant requiring different humidity conditions for processing, packaging, storing, personal comfort, etc. Numerous installations are illustrated, including those for the making of safety glass, food dehydrating, capsulating, processing of chemicals and drugs, etc.

National Airoil Burner Company, Inc., 1284 E. Sedgley Ave., Philadelphia 34, Pa., has issued Bulletin No. 65 featuring its low air pressure oil burners.

The attractive fifteen page booklet illustrates and describes various models and gives a description of the operation. Various charts and diagrams are included in the booklet and typical industrial installations are illustrated. The Airovent Centrifugal Blower is shown and described and charts and diagrams also are given for this section.

STRESS-OPTICAL TESTS . . .

(*Continued from page* 466)

Every joint comes within a certain range of coefficients of expansion, as e.g. the range round about 11×10^{-7}, or 40×10^{-7}, or 52×10^{-7}, or 96×10^{-7}. There is a standard glass for each range, which is used indiscriminately for the glasses, metals, and connecting glasses coming within that range.

Each sample of a certain standard glass must be perfectly equal to another sample of the same standard glass, which can be easily checked by applying the following glass test.

A. Glass test. Of the glass to be tested as well as of the standard glass a plate of approximately $1\times1\times0.3$ cm is made. This and also the subsequent operations are done in the flame of a glass-blower's burner (illuminating-gas/air, and, if necessary oxygen). These plates are polished on one side (viz. 1×0.3 cm) on a rotating fine-grained grindstone. Next they are sealed to one another in the flame of the above-mentioned burner so that one plate of a $2\times1\times0.3$ cm is obtained. The limiting-surface is fused for so short a time only that the transition between the two glasses remains visible.

Next this plate is put in a furnace the temperature of which is approximately 100° C higher than the transformation temperature of the glass to be tested. After this it is cooled down at the rate of approximately 2° C a minute[3] to a temperature at which the removal from the furnace will not produce fresh stresses owing to too rapid cooling (200-250° C). After complete cooling down there may only remain a permanent stress due to a difference in expansion between the two glasses. This permanent stress is largest at the limiting-surface of the two glasses and is measured there in the middle of the plate. At the sides there are stress-influencing effects.

The measurement is done by means of a polarizing microscope with crossed nicols on the lines of the methods known in crystal optics and the science of photo-elasticity. We are concerned with the measurement of the stress parallel to the limiting-surface. In the 45° position of the limiting-surface in reference to the polarizer and the analyzer, we see the field of vision light up, which field remains dark with crossed nicols if there is no plate. Then the plate is orientated as shown in Fig. 2. The lighting up is caused by the double refraction owing to stress in the glass plate.

The magnitude of it is measured by placing a so-called compensator in the beam of rays in the microscope-tube, which compensator brings about a larger or smaller amount of double refraction of a known value. We use a Berek compensator for the purpose. It is adjusted so that the double refraction produced by the plate is entirely counteracted by the compensator, which results in the darkening of the center of the field of vision (the point of intersection of the cross wires). Of course, this is only possible if the lead formed in the plate is counteracted by the compensator. However, if compensator and plate cooperate a more intense luminous effect will be the result. The plate should then be turned through 90°, to render compensation possible.

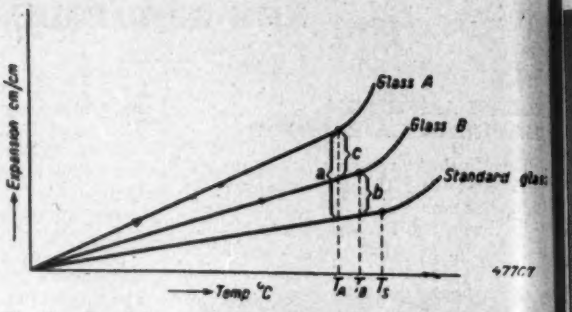


Fig. 3. Breakdown of subtraction rule when the temperatures of solidification (T_A and T_B) are different.

By taking the thickness of the plate into account, the double refraction, i.e. the stress, can be expressed in $m\mu$/cm.

Every lot of glass delivered by the glass-works is tested for the amount of stress by comparison with standard glass. The stress is invariably measured *in* the standard glass so that the values given always bear on stresses measured in the standard glass. This is especially of importance for the additions *C* (compression) or *T* (tension), seeing that compression in the standard glass means that the coefficient of expansion of the glass tested is higher than that of the standard glass, and vice versa.[4]

With one and the same kind of glass the variation in temperature of solidification is sufficiently small so that, within the limits of the accuracy of measurement, the following holds good:

If glass *A* occasions a stress *a* in the standard glass, and glass *B* a stress *b*, *A* and *B* have mutually a stress $a - b$ (*a* and *b* must be positive in the case of tension, and negative with compression). That is not so where the temperatures of solidification are unequal is shown by Fig. 3.

The stress between *A* and *B* is represented by *c*, which is not equal to $a - b$ (T_A, T_B and T_S are temperatures of solidification of the glasses *A* and *B* and of the standard glass respectively). We always found the subtraction rule confirmed *for one and the same kind of glass.*

Thus we have found the measure required to judge of the mutual adaptability of glasses. In comparison with expansion measurements the time actually required for the examination of the glass has been reduced to a minimum. One man, having no other training than that of elementary school but endowed with an adequate sense

(*Continued on page* 478)

[3]Differences in measuring results between the rate of cooling of 1 and 3 °C/min were not found.

[4]When there is doubt as to whether one has compression or tension, there is a simple procedure. One makes a bead from a glass metal combination of which it is known that the expansion of glass is greater than the expansion of the metal (for instance, one seals a fernico glass to a tungsten wire 0.05 cm in diameter). After cooling, the bead is placed in benzene and put under the polarizing microscope in one of the two 45° positions and the color is changed from red to blue or to yellow, depending on the 45° position chosen. But one knows also that the axial stress is a tension in the said example. Here one has an indication how to determine whether one has compression or tension in the glass under investigation, for similar color in the same position means similar stress.

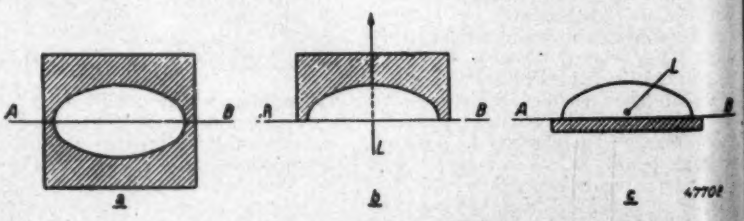
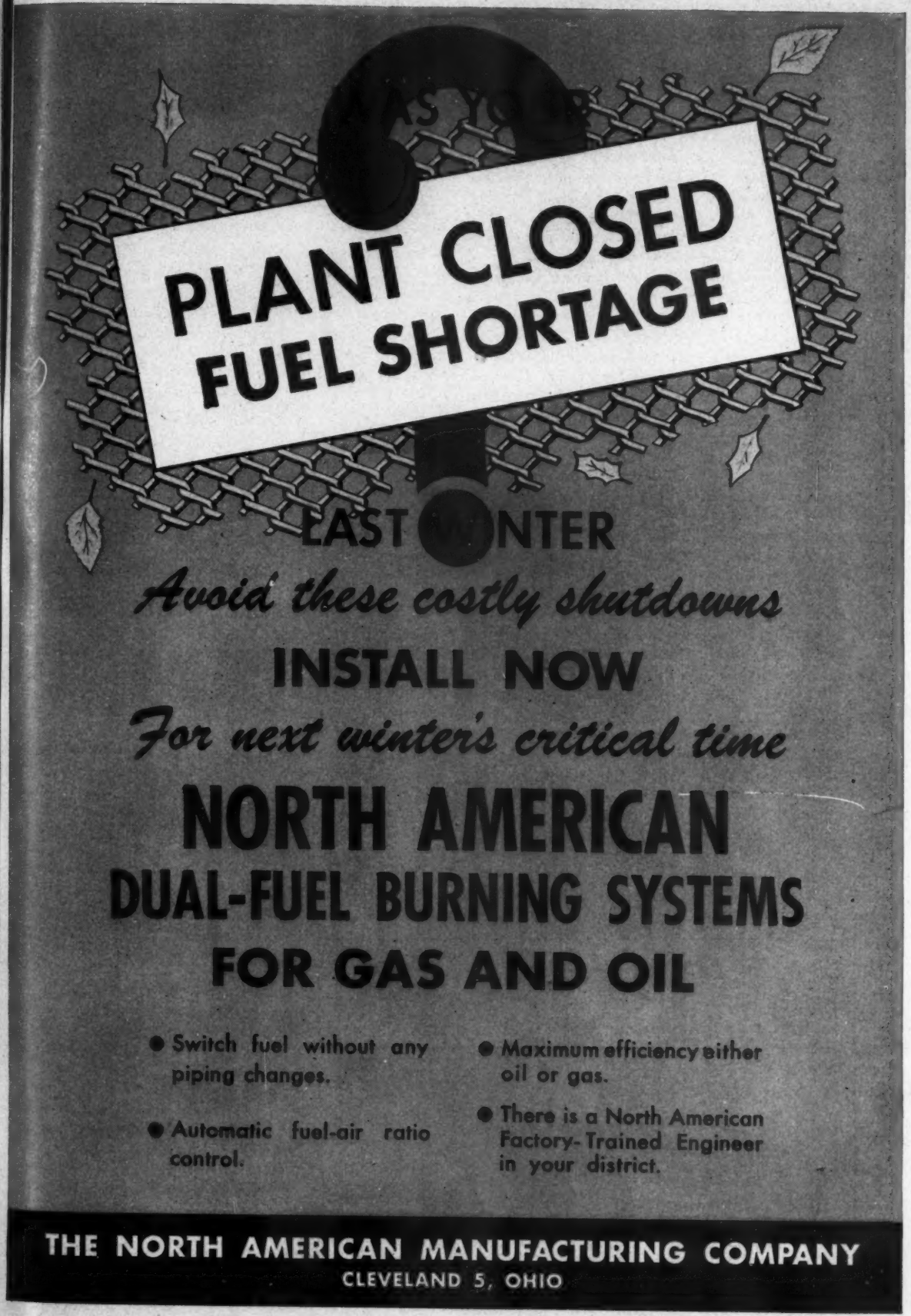


Fig. 4. a) A piece of sheet-metal with a drop of glass, b) the same after removing the part below *AB*, c) cross-section through *AB*; L = light ray.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CLEVELAND 5, OHIO

(*Continued from page* 476)

of accuracy, daily tests 10 to 15 samples, the results being known to the glass-works people six hours after receipt of the samples; this man enters the test data while the glass plates are cooling down.

The accuracy and reproducibility can be shown best as follows: If we see to it that a proper limiting-surface is obtained (as described above), the degree of accuracy of the measurements of various samples of the same glass amounts to $\pm$ 10 mμ/cm. Expressed in terms of coefficient of expansion this means for lime-glass a degree of accuracy of $\pm 0.15 \times 10^{-7}$. For measurements of a soda-lime-glass for guiding purposes only we have found a relation according to which 70 mμ/cm corresponds with a difference of about 1×10^{-7} in coefficient of expansion. It is true that the stress-optical coefficient is not equal for different kinds of glass, but with the current kinds of glass the range of this coefficient is sufficiently small to guarantee a satisfactory degree of accuracy, in particular for this type of glasses.

B. The metal test. There are three cases: a) metals available in the shape of sheets of a thickness more than 0.1 cm and less than e.g. 0.3 cm; b) metals available in the shape of sheets of a thickness of 0.1 cm or less (down to 0.05 cm); c) metals which are available as wire.

Sheet-metals thicker than those specified under a are fundamentally sealed on to the standard glasses in the same way as the glasses. After being ground the lateral face of the metal is polished and subjected to the same preliminary treatment as applied in the usual practice of metal joints (sometimes reduction in humid hydrogen, sometimes pre-oxidation in a furnace or a flame or otherwise). The glass sealed on to it lends itself to stress measurements.

Sheet-metals as specified under b, i.e. the thinner kinds, are treated in a different manner. It is not the lateral face but the top or the bottom face (so approximately 1×1 cm) that is ground and polished, etc. Next an oval drop of glass (length 1 cm, width 0.6 cm, height 0.6 cm) —see Fig. 4—is sealed on to the polished surface. After the glass has cooled down all the glass and metal below the line *A B* is entirely ground off. Next the ray of polarized light is allowed to pass in the direction *L*. Thus it is possible to measure the "stress" in cm of path.

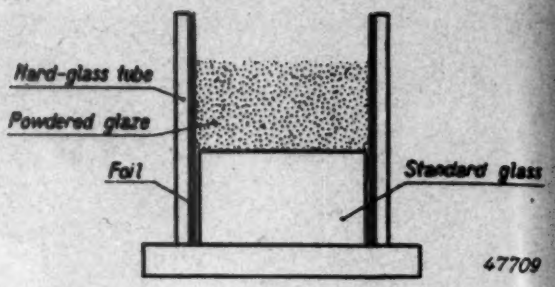

Fig. 5. Preparation of a test sample for a glaze.

It is not necessary to know whether a thicker sheet of the same metal produces a different amount of stress (which is e.g. the case with fernico, where it is only above a thickness of 0.14 cm that influences due to the thickness are no longer perceptible). The object in view is merely to have a measure for the special purpose which the thin sheet has to serve, and we have such a measure now.

Metal in the shape of wire is not tested in the way described above. We have made preparations for such a test, but up to now there has been no need of testing tungsten or molybdenum wire, because these are constant, and copper-clad wire is tested in a different way.

A method is being developed for testing chrome-iron wire, whereby a glass bead is formed around the wire and a certain ratio (3 : 1) is maintained between the diameters of the glass bead and the wire. In due course we may give further details.

C. Glaze test. Glazes are used if glasses of a higher softening point have to be sealed to one another whilst the parts inside the lamp or valve have to be heated as little as possible. They are tested by sealing them to the standard glass to be used. Owing to the great difference of softening temperature it is difficult to make a plate.

Therefore, another method is adopted. In a hard-glass tube (inside diameter approximately 1 cm, wall-thickness 0.1 cm) inside-coated with loose metallic foil (*Cu Al*), a plate of standard glass (approximately 1 cm in diameter, thickness 0.5 cm) is put. Upon this plate glaze-powder to a thickness of approximately 0.5 cm is strewn (Fig. 5).

The assembly is placed in a plate of asbestos or other material and the contents of the tube fused at the temperature applied in the glazing technique. After effective cooling down the cylinder is ejected from the tube, two parallel flat sides are ground at the surface of the cylinder, after which the measurement can be made in the same way as in the previous cases.

In order to avoid any trouble from roughness of the ground surfaces through which the rays of light must pass, the glass object is first immersed in benzene (or some other liquid whose index of refraction approaches that of glass). Benzene is also used with the other measurements referred to.

The method of testing glass and metal described in the present article has grown into a regular routine test

(*Continued on page* 480)

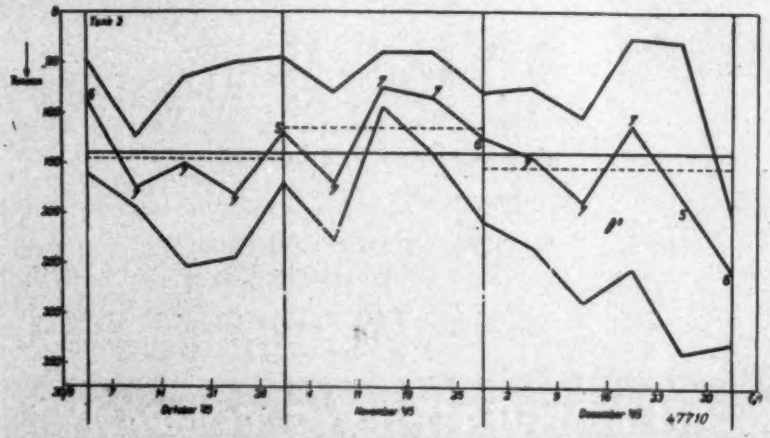

Fig. 6. Example of a graph showing variation of the tension with time for samples taken at regular intervals from one and the same tank.

THIS CORHART* BOTTOM HAS RUN FOR 3107 DAYS!

The Corhart* Standard Electrocast refining-end bottom shown above is now in its *sixth* campaign — on July 4, 1947, had finished 3107 operating days on flint bottle glass, and was still going strong!

The Corhart bottom blocks were originally 12" thick, insulated with 6" clay blocks.

Incidentally, the refining-end sidewalls are also the original Corhart Standard blocks that were installed six fires ago!

Here are the figures:

Campaign No. 1 — Aug. 29, '38 to Jan. 14, '40
Campaign No. 2 — Feb. 7, '40 to May 29, '41
Campaign No. 3 — June 23, '41 to Aug. 8, '42
Campaign No. 4 — Sept. 3, '42 to May 14, '44
Campaign No. 5 — June 15, '44 to Mar. 2, '47
Campaign No. 6 — Apr. 2, '47 to ????

This nine-year-old refining end furnishes convincing evidence that Corhart Electrocast produces maximum returns per refractory dollar.

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*Registered trade-mark.

QUALITY ECONOMY ENDURANCE

CORHART ELECTROCAST REFRACTORIES

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By order of the United States District Court for the Northern District of Ohio, Western Division, Owens-Illinois Glass Company offers for sale as a unit all real estate, buildings, machinery, production equipment (not including molds), tanks and furnaces (except experimental machinery and furnaces) located at Chicago Heights, Illinois, and which were a part of the assets acquired by Owens-Illinois Glass Company from Kimble Glass Company on July 1, 1946.

In accordance with the order of the Court such property is offered for sale for cash to any purchaser approved by said Court, subject to prior sale, at the fair market value of said property as a glassware manufacturing plant, as determined by an appraisal made by The Lloyd-Thomas Company, which said appraisal has been duly filed with the Clerk of said Court at Toledo, Ohio., where it may be inspected. Additions and improvements made to the property described above since July 1, 1946, and prior to consummation of sale are not included in the appraised value aforesaid but are offered for sale as a part of the unit for an additional consideration equal to the cost thereof to Owens-Illinois Glass Company.

In connection with the sale of the property and additions and improvements thereto above described, Owens-Illinois Glass Company will assign or cause to be assigned to the purchaser thereof for the consideration hereinafter set forth, all its rights in and to the following machinery and equipment leased from Hartford-Empire Company situate on said premises on July 1, 1946, to-wit:

4—4 head I S machines with feeders, revolving tube drives and motors, and variable speed drives and motors

1—5 head I S machine with same

2—36" x 74' lehrs, gas fired with top vertical discharge, motor driven steel plate exhaust fan, and all regular equipment

The consideration to be paid by the purchaser to Owens-Illinois Glass Company for the assignment of its rights in the leased machinery aforesaid shall be cash in such an amount as will reimburse Owens-Illinois Glass Company for a fair proportion of any and all payments made in connection with said leased machinery by Kimble Glass Company or Owens-Illinois Glass Company which may be considered as costs of installation, advance payments for minimum annual royalties, license fees, parts, insurance and taxes.

In the event of such sale, possession will be delivered not later than six months after the consummation of such sale to a purchaser approved by the said Court.

Address all inquiries to

Owens-Illinois Glass Company
Attention: F. G. Morfoot
P. O. Box 1035, Toledo 1, Ohio

STRESS-OPTICAL TESTS . . .

(*Continued from page* 478)

in the manufacture. Though figures are not of very great value to people without some knowledge of the joints under discussion, we shall nevertheless quote some as a guide.

Some Quantitative Data

The following table gives the limiting values measured in the standard glass. The values must fluctuate within these limits, lest production-shrinkage should occur owing to poor adaptation.

Kind of glass or metal	Admissible stress in mμ/cm in corresponding standard glass. *C* = compressive stress; *T* = tensile stress	Remarks
lime-glass for incandescent lamps	300 *T*-200 *C* in standard glass *X*	in normal cases
ditto	300 *T*- 0 in standard glass *X*	for special difficult cases
lead-glass for lamp stems	200 *T*-250 *C* in standard glass *Y*	in normal cases
alkali alumo boro silicate glass	200 *T*-100 *C* in standard glass *Z*	for difficult glass-metal joints
fernico (iron-nickel-cobalt alloy)	0 -300 *C* in standard glass *Z*	for normal fernico cases, thickness 0.15 cm
chrome-iron	200 *C*-500 *C* in standard glass *Y*	for normal chrome-iron cases, thickness 0.15 cm

The accompanying graph (Fig. 6) shows the variations of the values of a certain glass from a certain tank. There are three broken lines: the upper and lower ones are the extreme values which occurred, the line in between constituting the arithmetical mean. Every week we noted down in the graph the points that determined the shape of this line. The figures on the mean value line indicates the number of drawings of the week in question.

The horizontal dash line represents the monthly average, the horizontal drawn line the three-monthly average.

In conclusion it should be mentioned that the laboratory assistants J. F. M. Korteweg and J. de Vries have taken an active part in the development and execution of the test methods described.

ROBERT SWINDELL ELECTED PRESIDENT OF SWINDELL BROTHERS

At a recent meeting of the Board of Direction of Swindell Brothers, Inc., Robert H. Swindell was elected President. Prior to his election, Mr. Swindell was Secretary and a Director. He has been associated with the company since 1930. Mr. Swindell is the great-grandson of one of the founders of Swindell Brothers, Inc.

At the same time, it was announced that Joseph B. Scott, formerly Vice President and Sales Manager, was named General Manager. Mr. Scott is a member of the Board. He will continue to direct sales.

John J. Jeffries, member of the Board and Vice President, will remain in charge of finance, taxes, insurance and labor relations, it was announced. Walter S. Nuckols, Manager of the New York office and a Board member, was named Vice President. Controller Robert B. Hamill was elected Secretary and Treasurer.

PLANT OVER MINE! The Pacific Coast Borax Company's modern concentrating plant is located directly above their borate of soda deposit. Ore, hoisted from the mine in two huge skips, is automatically dumped into storage bins, passed through the concentrating process, and shipped by railroad to the company's refinery at Wilmington, California.

VISCOSITY • • • A glass melt of optimum viscosity can be more easily and rapidly fined, thus speeding the overall melting operation and contribute to an increased tank output. The proper amount of B_2O_3 in the melt will help to maintain this viscosity.

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PACIFIC COAST BORAX COMPANY

51 MADISON AVENUE, NEW YORK 10, N. Y.

COLORED GLASSES . . .

(*Continued from page 464*)

term solarization is used to describe these color changes. Solarization in this sense is only one particular form of photochemical reactions which are caused by the transformation of a part of the radiant energy absorbed by glass into chemical energy.

Dr. Weyl shows that the treatment of these photochemical reactions cannot be separated from that of fluorescence; both are phenomena in which radiant energy is transformed into other forms. Fluorescence occurs when any part of the absorbed radiant energy is reemitted as visible light. In this case the electronic structure has undergone a change which is instantaneously reverted to its original condition by the liberation of radiation equal to or lower than the absorbed energy.

If the change remains stable for a measurable period of time, it might be described as a chemical change. Reversion to the original chemical state is accompanied by an afterglow. Because it may be thought of as released by a chemical reaction, this luminescence is sometimes termed chemoluminescence.

If the change is "permanent" a photochemical reaction has taken place and when the radiation absorbed was sunlight, the process is known as solarization.

Glass may be reverted from a state of solarization by high temperature (which may cause a luminescence called thermoluminescence), by exposure to long wave radiation or by storage in the dark.

In his discussion Dr. Weyl makes it apparent that no strict boundary can be drawn between purely physical fluorescence and photochemical processes leading to permanent changes of chemical nature such as discoloration. The distinction is only one of degree.

That part of the radiant energy absorbed by the glass which cannot be accounted for as reemitted fluorescence, or as a photochemical change such as solarization, has been dissipated as thermal energy causing a slight increase of temperature in the irradiated glass.

The general introduction of the paper is followed by a very extensive historical survey which credits the first description of the purple coloration of manganese containing glass in sunlight to Faraday (1825).

Solarization of Manganese Glass

The explanation of the purple color of solarized manganese glasses was first given by Pelouze in 1867 and may still be maintained in the modern version:

$$Fe^{2+} + Mn^{2+} = Mn^{3+} + Fe^{2+}$$

faint pink deep purple

Arsenic or antimony, changing from pentavalent to trivalent states may substitute for iron:

$$As^{5+} + 2\ Mn^{2+} = 2\ Mn^{3+} + As^{3+}$$
$$Sb^{5+} + 2\ Mn^{2+} = 2\ Mn^{3+} + Sb^{3+}$$

Dr. Weyl emphasizes the fact that electrons lost by one ion need not necessarily be taken up by the other ion in a pair, as Pelouze's classical concept seems to postulate.

Thus the following reaction may occur:

$$Mn^{2+} + 6.55 \times 10^{-27}V = Mn + \text{electron}$$

The term $6.55 \times 10^{-27}V$ represents the energy of light radiation of frequency V.

The electron released in this reaction may be trapped somewhere in imperfect locations of the glass structure.

Processes of this type can be promoted or inhibited by other ions capable of capturing or furnishing electrons. From a practical viewpoint solarization is considered undesirable. More interest, therefore, is being expressed for "desensitizers" which would prevent excessive solarization. The term is coined in analogy with the related process of photography. Unfortunately almost no experimental data are available at this time on sensitizing or desensitizing the solarization of glass.

Solarization of Other Glasses

Other pairs than manganese and iron may cause trouble by a similar reaction. Examples given include:

$Ce^{3+} + V^{3+} = Ce^{4+} + V^{2+}$ (green to purple)

$Ce^{3+} + Cu^{2+} = Ce^{4+} + Cu^{+}$ (blue fades)

The most active participants in solarization reactions are iron, titanium, arsenic, antimony, manganese and cerium. As a rule, a pair of these ions have to be present.

In flint glasses arsenic alone may cause solarization. The underlying reactions are:

$As^{3+} + 6.55 \times 10^{-27}V = As^{5+} + 2$ electrons

$As^{3+} + 3$ electrons $= As^{\circ}$

The end product, As°, elemental arsenic, appears as a brown discoloration.

Changes in UV Transmission

The previously mentioned ions are only a few of those capable of changes under irradiation as the energy of the radiation increases from visible light to UV of shorter wave length. The alkali ions are responsible for the absorption in the short wave length area. If the irradiation possesses the high energy corresponding to $\lambda = 2000$ to 2500 Angstrom, alkali ions most readily accept electrons and become alkali atoms. Discoloration is observed and the transmission in the UV above 3000 A decreases. Weyl shows in which manner alkali ions at exposed places, which may be called flaws of the glass structure, predominate in the absorption mechanism.

There exists a veritable "equilibrium of solarization" in the sense that the condition of absorption depends on the wave length of irradiation. The absorption which is increased by short wave irradiation is reversibly decreased by long wave rays such as visible light of 4000 A°. Weyl, in using the term solarization equilibrium includes radiation beyond the visible light.

N. J. Kreidl

BLUE RIDGE GLASS NAMES SALES PROMOTION MANAGER

The resignation of C. B. Duke as Sales Promotion Manager has been announced by the Blue Ridge Glass Corporation. Mr. Duke is resigning to devote his full time to the operation of Holston Glass Company, Inc., which he has operated for the past two years.

Succeeding Mr. Duke is James S. Herbert. Mr. Herbert is familiar with the company's manufacturing operations and was formerly Sales Engineer with the company.

• Cambridge Wire Cloth Company has appointed Leslie F. Moody, Oakland, California, as sales engineer to cover the state of California.

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- Salt Cake (Sodium Sulfate)
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CONVENTION OF THE CZECHOSLOVAK CERAMIC AND GLASS SOCIETY

The first convention of the recently united Czechoslovak Ceramic and Glass Society took place this spring (May 10-14, 1947) in the hot spring resort place of Trencianske Teplice, Slovakia.

The Glass Division of the Society met on May 11. The chairman of the Division, J. Hrnicko, who is now visiting the Americas, was represented by the vice-chairman, S. Cimburek, section chief of the Ministry of Industry. The Glass Division now has 82 members, a number too small in the opinion of the main speaker at the general session, Dr. Ctyroky, if compared to the total number of glass technologists in the country.

The following committees were constituted: (1) Furnace Construction and Heat Economy (chairman: P. Geschmay), (2) Technical Museum (V. Ctyroky), (3) Normalization (K. Brabenec, director, Union Glass Works), (4) Glass Education (Professor A. Metelak, Glass School, Zelezny Brod), (5) Science (V. Ctyroky).

Local sections are planned in Teplice-Sanov (Northern Bohemia) and Bratislava (Slovakia).

Technical papers* were read in the afternoon and were of a review character. 1) J. Barta: The History of the Slovak Glass Industry; 2) K. Brabenec: Drawn Flat Glass; 3) V. Ctyroky: Progress of the Global Glass Industry. In this paper the stress was on the progress of electrical melting in Switzerland, France, Belgium and the Scandinavian countries. The greatest technological accomplishments are credited to the United States. The speaker exemplified these accomplishments by A. Pincus' phosphate glass, Kuan Han Sun's beryllium containing glasses, Corning's oven ware, tempered glass and Preston's work on the control of bottle quality. The use of zirconia in Corhart blocks (Corhart 2) and the properties of Alfrax were examples of new refractory materials. Engineering and economic facts typical of the American industry were discussed; 4) M. Fanderlik: Annealing of Glass from the Practical and Theoretical Viewpoint. Hartford and Amco lehrs are described and compared with new Belgian lehrs. The "freezing" type of annealing is briefly reviewed and credited to work by Morey, Taylor, Winter, McMaster and Fanderlik; 5) P. Geschmay: Importance of Heat Economy in the Glass Industry; and 6) F. Kotsmid: Heat Balance of a Furnace.

*See Sklarske Rozhledy *23* (2, 3) 34-50 (1947).

BROWN INSTRUMENT SCHOOL TO START SEPTEMBER 15

The Brown Instrument Company has announced that it will start its twelfth consecutive year of conducting continuing courses of training in industrial measuring and control devices at its school of instrumentation in Philadelphia.

The course will include instruction in pyrometers, continuous balance electronic potentiometers, electrical and air-operated automatic controls, flow meters and thermometers.

• L. R. Garretson, Advertising Manager of Leeds & Northrup Company since 1925, has announced his retirement made necessary by the condition of his health. Mr. Garretson's successor is Kenneth W. Connors, who has been a member of the Advertising Division since 1934.

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Factory and Laboratories: Washington, Pa.

(*Continued from page 462*)

quirements in the productive processes of manufacture, access to raw material, transportation systems, or markets may be more important factors in plant location than the single element of power supply. There is, naturally, the possibility that factors surrounding power requirements may favor the location of a power plant in an inland location removed from cooling water supply in which case nuclear energy would offer some advantages.

A second proposal is the production of power by means of an atomic powered gas turbine. This is merely another method of producing electrical power and, as such, will contribute no revolutionary element in the question of power supply. It is of interest because of a possibly more efficient converter of energy than the steam turbine. It cannot promise drastically reduced costs of electrical power.

A third proposal is the production of steam or the heating of water or air for process or for space heating. Especially intriguing is the project of central heating of homes in urban centers with the accompanying promise of smokeless cities. A community or a portion of a community heated by a central plant raising steam with existing fuels is not unknown at the present time. The promise of smoke-free cities does not necessarily require the use of nuclear energy as the source of heat. This can also be effectively accomplished with a central heating system using coal. It should be pointed out that the smoke nuisance in a city comes, not from the large industrial or public utility chimneys but from the thousands of homes equipped with coal burning furnaces or space heaters. If central heating is not widely used at present, it is for reasons other than the availability of fuel.

The somewhat extended discussion of the method and form in which nuclear energy can be produced is merely intended to lay the ground work for a discussion of the relationship of this form of energy to existing fuel forms. "In all probability, its (nuclear energy) most immediate application will be for marine use and for generating power in isolated regions where other cheap power resources are not available."[5]

The construction of a nuclear powered electrical power plant for the reduction of alumina near the source of ore might be considered as a feasible project, provided a low cost water power site were not available and other fuels by reason of transportation costs were unavailable. The use of nuclear energy as means of transforming coal-less or oil-less regions into industrialized nations, as is envisioned by some of the more enthusiastic proponents of the possibilities of this form of power, must be considered with sharp reservations. This consideration assumes that nuclear energy is sufficient to lay the basis of industrialism independently of the use of other fuels. The fallacy of this lies in the fact that electrical power, in which form nuclear energy can feasibly be harnessed, has an exceedingly limited quantitative and functional application in industrial production. In the United States, for example, electrical power in manufacturing represents an equivalent of coal consumption of 46 million tons in a prewar year, 1939, or 78 million tons in the highest war year. Industrial production involves not only the fabrication of goods in a plant but transportation, in vast tonnages, of raw materials to the plant and manufactured goods from plant to consumer, and of mining and smelting of ores. All these operations require either coke for smelting or coal or oil for the fueling of mobile power units. The fact is that power from nuclear sources cannot be utilized extensively independently of coal and oil fuels. One may, for example, analyze the requirements for industrialization in South America, a region which may be correctly described as technologically undeveloped. This area ought to be an ideal testing ground for an industrialization based upon nuclear energy. In Brazil is located one of the major high grade iron ore deposits of the world—together with power primary requisite for industrialization. In support of this basic industrial material, there is in South America an ample food producing area, several steel alloying minerals, adequate copper supplies, timber and oil. Only coal is lacking in quantity and the meagre resources are low in quality.

If this continent is to be industrialized, a way must be found to smelt iron ores, cheaply and in large tonnages. There is nothing to indicate that nuclear energy can be controlled in such a manner as to accomplish this task. The author refuses to venture any opinion as to its ultimate possibility. But unless an accomplishment as revolutionary as this can be accomplished, the industrialization of coal-less nations appears somewhat remote.

Summary

This brief review of fuel supply in American industry has sought to emphasize the diversity of fuel requirements and the high degree of preparation of certain types of fuel necessary to make the industrial processes function. Too often, the mere presence of raw fuel resources, regardless of their quality, is regarded as ample for the inception of a program of industrialization. A review of the multiple and varied forms of power and heat resources in a complex industrial society indicate the exacting demands upon our fuel supply and the need of a detailed understanding of our available fuel resources. This article can only state the nature of the problem.

[5]Edgar J. Murphy, in *Chemical and Engineering News*, Vol. 24, No. 11, June 10, 1946, p. 1515.

KIMBLE APPOINTMENTS

The Kimble Glass Division of the Owens-Illinois Glass Company has announced the appointment of J. A. Serra as Manager of a new Sales and Service Control Division. The division's functions will include sales reports, forecasts and long-range production planning. Mr. Serra has been associated with the Tin Decorating Company and Owens-Illinois Can Company, both companies having been bought by Owens-Illinois Glass Company.

Fred D. Snyder has been named Director of Labor Relations for the Kimble Division. He has been associated with Kimble Glass since 1923. Stuart A. Kenworthy was named Plant Manager of the Vineland plant. He will be in complete charge of all manufacturing operations at Vineland, as well as Conshohocken, Pa., and Camden and Pleasantville, New Jersey.

The appointment of J. H. Cooper as Personnel Director of the Kimble Glass plant on Westwood Avenue was also announced. Mr. Cooper will assume full responsibility for the personnel program at the local plant as soon as all Closure operating facilities and equipment are removed to the new St. Charles, Illinois, plant.

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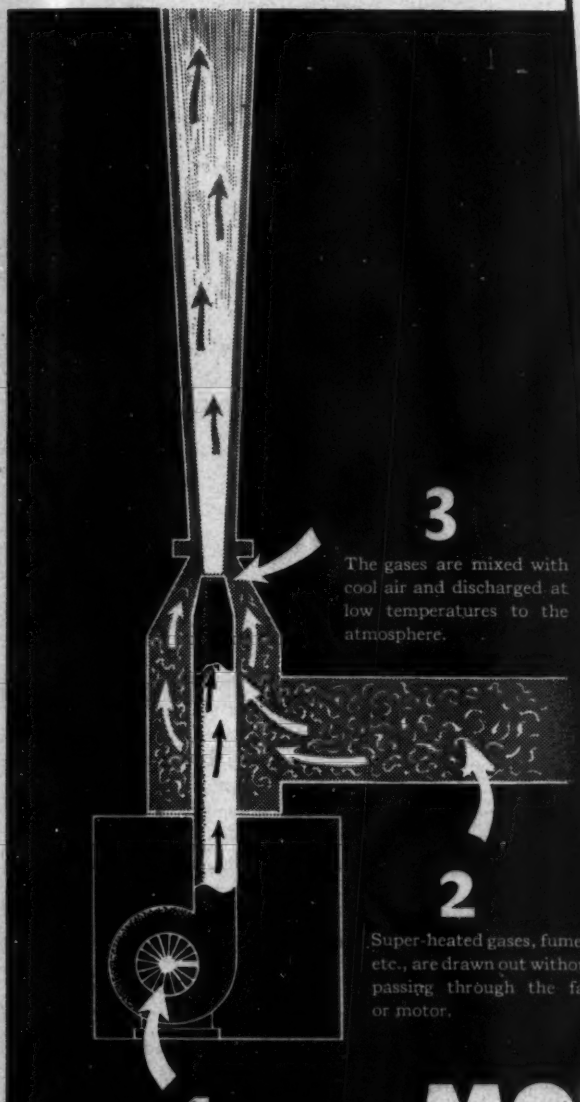
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The gases are mixed with cool air and discharged at low temperatures to the atmosphere.
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INVENTIONS AND INVENTORS . . .

(*Continued from page* 469)

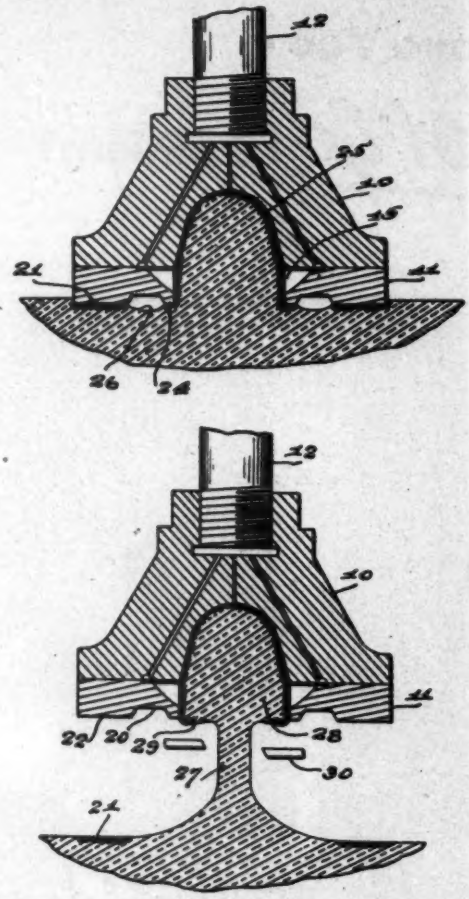


Fig. 5. Owens Method of Gathering Glass.

It is the invention of Herbert H. Greger and John J. Reimer of Washington, D. C., who assigned it to The Briggs Filtration Company of Bethesda, Md. It is well known that the addition of material such as sodium silicate would reduce the melting point of this material. This invention uses an aluminum phosphate binder and provides an air setting plastic which has high strength under high temperatures. It is also easy to apply and has slight shrinkage.

Four examples of the composition are given, of which the following, known as "P23K," will serve as an example:

	Parts
—4+20 mesh fire clay grog	45.00
—35+48 mesh calcined kyanite	2.51
—48+100 mesh calcined kyanite	2.73
—100 mesh calcined kyanite	19.10
Kentucky ball clay No. 4	7.61
Georgia kaolin	7.82
Sesqui aluminum phosphate	5.23
Water	10.00
	100.00

Three other examples are given, all having a pyrometric cone equivalent equal to standard cone 34. This material is covered by 30 claims in the patent. It is unusual that this patent contains no references to patents or publications cited by the Patent Office.

Owens Method of Gathering. Fig. 5, Patent No. 2,425,-592. This patent shows a method of gathering glass from a pool and it would seem to be adapted for use with the well known Westlake machine. It is the invention of George R. Bowe, Jr., who assigned it to Owens-Illinois Glass Company. In suction gathering, there is commonly a "cut-off scar" in the finished ware, caused by the cutting off of the glass connecting that in the suction cup with that in the pool. This invention avoids this scar by thinning out the glass connecting that in the cup with that in the pool.

The upper part of the figure shows a section through the mold where the body 10 has a disk 11 which contacts the glass in the pool. This is carried on the lower end of a spindle 12 and connections are provided to a vacuum system. The glass engaging portion of the disk 11 is shaped so as to produce an annular chilled surface 21 and a smaller diameter annular chilled surface 24. Between these two chilled surfaces, there is an annular surface 26 which has not been in contact with the mold and therefore is still hot and fluent.

When the mold is lifted, as shown in the lower part of the figure, a thin neck 27 is formed which may be severed by the usual shears 30. This unusual thin neck is apparently produced by the chilled annular ring of glass 21 which encloses the hotter ring 26. In order to obtain the desired results, proportions about as shown in the drawing should be followed.

The following references are of record in the file of this patent: United States Patents: 2,292,370, Ferngren, Aug. 11, 1942; 1,792,988, Kadow, Feb. 17, 1931; 1,983,-816, Schwalbe, Dec. 11, 1934; 2,290,012, Barnard et al., July 14, 1942; 1,008,464, Healy, Nov. 14, 1911; 1,674,-529, Spinasse, June 19, 1928; 2,046,195, Tremblay, June 30, 1936; and 1,272,652, Francart, July 16, 1918.

LACLEDE-CHRISTY PURCHASES OSCEOLA SILICA & FIREBRICK COMPANY

The purchase by Laclede-Christy Clay Products Company of all of the capital stock of the Osceola Silica & Firebrick Company has recently been announced. It was stated that the purchase of this company was made out of working capital. Annual capacity of the plant is 10,000,000 fire brick. The plant is located at Osceola Mills, Pa., which is in the heart of the well-known Clearfield County fire clay district.

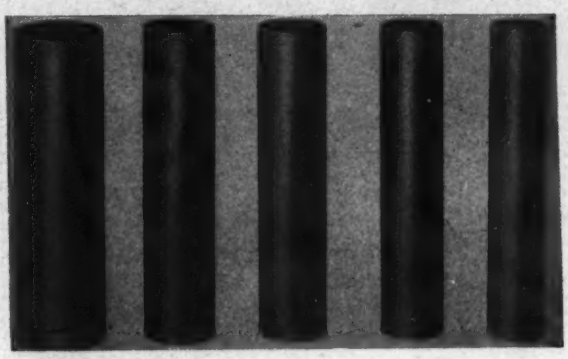
Albert B. Agnew, associated with Harbison-Walker Refractories Company for over thirty years, has been named General Manager of the Osceola Company.

Announcement has also been made by Laclede-Christy of the appointment of Julius A. Kayser as Assistant to the President, Donald N. Watkins. Mr. Kayser has been associated with the company for 24 years and has served in the Research, Operating and Sales Departments.

DR. SILVERMAN TO REPRESENT A.C.S.

Dr. Alexander Silverman, Head of the Department of Chemistry, University of Pittsburgh, has been appointed a member of the Division of Chemistry and Chemical Technology of the National Research Council to represent the American Ceramic Society for the three-year period ending June 30, 1950.

GUNITE



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RESEARCH DIGEST . . .

(*Continued from page* 470)

The addition of erbium oxide (Er_2O_3) in an amount of 10 per cent gives rise to one strong absorption band at about 1.52 μ and two weaker bands at about 0.80 and 0.95 μ, respectively. A comparison with the transmission curve for gadolinium which probably produces but little or no absorption in the infrared between 0.6 and 4.5 μ, indicates no other important absorption bands shorter than 4.5 μ. Absorption in the visible spectrum gives this glass a light-pink color.

The addition of vanadium (V_2O_5), cobalt (CoO), nickel (NiO) or uranium (U_2O_3) oxide in small amounts produces strong absorption bands in the spectral region between 1 and 4 μ. It is to be noted that much smaller concentrations of these metals were required to produce absorption of magnitude similar to that resulting from the addition of 10 per cent of some of the rare earth oxides. In the case of the addition of chromium (Cr_2O_3) and manganese (MnO_2) oxides, little change in absorption occurs within the near infrared region.

According to the work of Kiess, Humphreys and Laun upon its atomic spectrum, uranium is a rare earth type element and is the homologue of neodymium. It has the same valence electron structure and we would expect, therefore, its behavior would be similar to neodymium.

Each of the metal oxides also produces a large amount of absorption in the visible spectrum resulting in a distinct color for each glass. The colors resulting in glasses of this group are as follows for the different oxides: cobalt, pale blue; nickel, light to dark smoke to dark purple; vanadium, light yellow to yellow green (similar to novial B); uranium, light yellow (near novial C); chromium, green to yellowish green; and manganese, amethyst.

PITTSBURGH PLATE MAKES APPOINTMENTS

In a move to correlate the sales activities of the Columbia Chemical Division of Pittsburgh Plate Glass Company and the Southern Alkali Corporation, a subsidiary of the company, announcement has been made of the appointment of W. I. Galliher as executive Sales Manager of both units.

Mr. Galliher joined Columbia Chemical Division in 1931 and was formerly Director of Sales for the division's heavy industrial chemical products. In 1943, he was appointed executive Sales Manager of the Division.

At the same time, it was announced that Robert L. Hutchison has been named General Superintendent of the Columbia Chemical Division and E. Wayne Haley has been appointed Director of Sales for the Southern Alkali Corporation.

Mr. Hutchison has been associated with the firm since 1925 and has served in engineering, maintenance and construction, and as Superintendent of the Columbia Chemical Division's plant at Barberton, Ohio. Mr. Haley joined Southern Alkali Corporation in 1935 and has been Assistant Director of Sales during the past twelve years.

H. W. Gleichert will continue as Director of Sales for the Columbia Chemical Division and Robert M. Simpson has been named acting District Manager for the Chicago territory of the Division.

RECENT TRANSLATIONS OF RUSSIAN PAPERS . . .

(*Continued from page 467*)

tween them; this arrangement is suggested from a theoretical consideration of the heat flow.) The next section should, on the contrary, be heat insulated as it includes the temperature range of annealing. The cooling along the third section should be accelerated by cold air blast.

The temperature gradient along the sheet is not the only one to be watched. The difference of temperatures between the inside and the surface of the sheet also can become dangerous. This difference depends on the transparency of the glass for heat radiation. The higher this transparency, the more rapid is the equalization of temperature and the greater is the safe speed of withdrawal. Blue cobalt glass which strongly absorbs long waves (infrared) cannot be drawn on a Fourcault machine while red glasses are suitable for it.

Among the usual glass constituents ferrous oxide has the greatest unfavorable effect on the transparency of glass for infrared. Glass factories using batches with a low iron content achieve a higher speed of withdrawal than similar factories employing raw materials rich in iron.

The temperature gradient between the edges of a glass sheet and its central part is also dangerous. It can be reduced by avoiding non-uniform air flow around the sheet. A new construction of asbestos rolls may be of use in this respect as these rolls interrupt the flow of air along the wide faces of the sheet.

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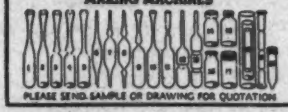

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GLASS LITERATURE IN GERMANY

Before the war the following periodicals were published: 1) *Glastechnische Berichte*, Frankfurt a.M., Ed. Dr. H. Maurach, Honorary Secretary Glastechnische Gesellschaft. The last issue (12/12/1943) appeared, one year late, at the end of 1944; 2) *Sprechsaal, Coburg, Publ:* Mueller and Schmidt, later united with Keramische Rundschau. Appeared regularly to the end of 1944; and 3) *Die Glasuette*, Dresden. Appeared last, under the name of "Glas", 1944/45 (2 issues only).

The two periodicals pertaining to flat glass (*"Die Deutsche Glaserzeitung"* Berlin, Publ: Holzmann and *"Diamant"*, Leipzig, could not reappear either.

Because of the extreme shortage of paper and the formalities of licensing, no periodical could be published again after the war. In the Russian zone, the licensing of *"Glashuette"* is expected soon. There is a great demand for the reappearance of *"Glastechnische Berichte"* which used to contain contributions from research and plant laboratories essential for the development of glass technology. Measures have been taken to make a new start possible and to maintain the high level of this publication.

A pamphlet by Dr. H. Maurach, "Glass in a New World", is concerned with the necessity of the promotion of glass technology and criticizes strongly the past impediments. He stresses the importance and the successful application of glass technology in the allied war effort and calls for the international collaboration of prewar days. The pamphlet represents an appeal to the "glass technological conscience" of German experts.

CONTINUED SHORTAGE OF BOTTLES IN BRITAIN

A shortage of medicine bottles, part of a general shortage of glassware, continues to hit all manufacturers in Great Britain who pack in glass. The situation has deteriorated to the point where certain pharmaceutical firms find it impossible to distribute their products in certain sizes until they receive fresh deliveries of bottles. These are given as and when manufacturers find it possible to do so.

A certain priority is given, of course, for export and this has the effect of facilitating very considerably the distribution of such products to overseas markets although probably at the expense of home users.

The production of bottles is linked very closely to the availability of coal and the principal cause of the present British shortage is the continuing effect of the fuel crisis during the winter of 1946.

There is no guarantee that similar conditions will not recur this winter and again hinder the recovery of the glass container industry.

In the perfumery and cosmetic fields, there is a continuing shortage of quality bottles, some of which are imported and some of which are home produced.

Although to some extent distillers enjoy priority, especially where export trade is concerned, the situation is essentially a hand-to-mouth one with no real element of security. The fact that Scotch whisky is now being sold in imported Dutch bottles demonstrates the acute situation which has developed in the glass manufacturing and packaging industries in Great Britain.

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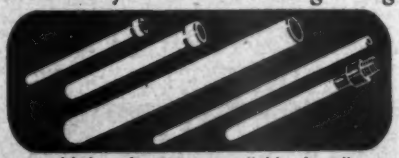

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